RECLAMATION

Managing Water in the West

Klamath River Dam Removals – Team Review of A/E Study

Klamath Hydroelectric Project
FERC License No. 2082
Oregon - California

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U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

KLAMATH RIVER DAM REMOVALS

TEAM REVIEW OF A/E STUDY

Table of Contents

Executive Summary

The Klamath Hydroelectric Project (Project) is owned by PacifiCorp, and includes four generating developments along the mainstem of the Upper Klamath River between river mile (RM) 190 and 228. The Project is currently undergoing relicensing proceedings before the Federal Energy Regulatory Commission (FERC). The East Side and West Side Developments are located further upstream at the Bureau of Reclamation's (Reclamation's) Link River Dam at RM 254, and have been proposed by PacifiCorp for decommissioning. The Project also includes a re-regulation dam with no generation facilities (Keno Dam), and a generating development on Fall Creek, a tributary to the Klamath River at RM 196. The State Coastal Conservancy (Conservancy) of California has contracted with an A/E firm, Gathard Engineering Consulting (GEC), and with Shannon and Wilson, Inc. (S&W) to characterize the sediment impounded by the four lowermost dams on the Klamath River (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams), evaluate the potential downstream effects of reservoir sediment erosion, and develop a feasible method of removing the four dams, including the preparation of cost estimates and construction schedules. Costs for removing the four dams, providing water quality protection and construction management, and developing engineering and permitting documents were estimated to be approximately $88 million in the final (November 2006) GEC report. The GEC report was intended to provide an overview (or feasibility) analysis of dam removal and its effects on downstream water quality, and acknowledged that additional analyses would be required to fully evaluate dam removal as a preferred management alternative. GEC was provided limited access to the dams and appurtenant structures to conduct its study. Full access was provided to the reservoirs for sediment sampling.

The Final Environmental Impact Statement (EIS) for the Klamath Hydroelectric Project (FERC No. 2082) was issued by FERC in November 2007. The Final EIS contains Staff evaluations of the proposal submitted by PacifiCorp for continued operation of five of the six Project generating developments with new environmental measures, in addition to alternatives developed by the Staff for relicensing the Project. Project alternatives proposed in the Final EIS include the Staff Alternative, which incorporates most of PacifiCorp's proposed environmental measures with some modifications; the Staff Alternative with Mandatory Conditions, which requires the installation of fishways at each development; and two Staff dam removal alternatives, which include (1) the removal of Copco No. 1 and Iron Gate Dams, and the installation of fishways at Copco No. 2 Dam and J.C. Boyle Dam, and (2) the removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams.

Reclamation's Klamath Basin Area Office (KBAO) and Mid-Pacific (MP) Region, acting on behalf of the Department of the Interior (Interior), requested Reclamation's Technical Service Center (TSC) perform an in-depth review of the GEC study report, cost estimates, and associated appendices and technical memoranda, and prepare a report documenting the findings of the TSC Review Team (Team). This report provides an assessment of the overall design level of the study using Reclamation guidelines, and summarizes significant comments into recommendations. A review and evaluation of the FERC Staff dam removal plans is beyond the scope of this study.

The GEC report presents a general study on the removal of Iron Gate, Copco No. 2, Copco No. 1, and J.C. Boyle Dams. The GEC report contains the following items:

1. General hydrologic and geologic descriptions of the river;
2. Analysis of sediment volumes stored in the reservoirs;
3. Reporting of sediment composition;
4. Description of various reservoir drawdown approaches;
5. Description of a proposed dam removal strategy;
6. General description of project impacts; and
7. Cost estimates of proposed dam removal strategy.

The GEC report represents a reasonable effort at developing a method and cost of dam removal at each site when considering the uncertainties remaining at this level of study. These uncertainties, of course, have an impact on the accuracy of the cost estimate. The cost estimates developed by GEC for removal of all four dams required many assumptions due to the limited available data and the uncertainties regarding the reservoir drawdown rate, the size of diversion flood for design, and overall timing of removal activities. Reservoir drawdown rates are generally controlled by the natural slopes on the reservoir rim rather than by the engineered slopes of an embankment. A cursory review of the reservoir rim at each site has not revealed any obvious stability problems; however, as more detailed dam removal plans are developed, additional studies should be performed to determine the potential for large landslides. During removal of the embankment dams, adequate freeboard must be maintained between the elevation of the excavated embankment surface or upstream cofferdam and the reservoir to prevent overtopping and potential failure. The freeboard would be dictated by the amount of flood protection that is desired (in terms of diversion flood return period) during the removal operation.

The Team believes that the mechanical and electrical equipment removal costs will be significantly greater than estimated by GEC due to the remoteness of each site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Although there were no known hazardous materials identified at the time of the Team's site visit, there may be asbestos, bearing and hydraulic control system oils, PCB's, or coatings containing heavy metals in the powerplants and on the exterior surfaces of the steel penstock pipes, surge tanks, bulkhead gates, and gantry cranes which would need specialized abatement requirements with associated costs.

The methods used by GEC to analyze the physical and chemical properties of the sediments are adequate and the number of samples collected seems reasonable for an appraisal-level analysis[1]. Approximately 26 samples were collected in the reservoirs and none of these samples contained hazardous material based upon criteria established under the Puget Sound Dredged Disposal Analysis program. The samples were spaced

[1] Appraisal-level designs and cost estimates represent an early stage of project development based on available data, and are used to determine whether more detailed investigations of a potential project are justified. Reclamation does not use appraisal-level cost estimates to seek Congressional authorization.

throughout the reservoirs in a reasonable manner, but only one sample was collected at a depth greater than 10 feet of the sediment stored in the reservoir. Considering the size of the impoundments and the costs of removal, the Team recommends collecting additional samples for feasibility design[2]. There would be three reasons for collecting additional samples: 1) to verify the absence of hazardous material at all sediment depths, 2) to obtain physical sediment properties at all sediment depths, and 3) to improve the estimate of the stored sediment volume. The Team believes that it is highly unlikely that hazardous materials exist in the reservoir sediment because with 26 samples collected there would have been at least some indication of contamination. However, this needs to be verified at all sediment depths and for more locations within the reservoir. Obtaining physical properties at all sediment depths will assist in quantifying the consolidation of the material, which is important to defining its erosion characteristics. The uncertainties in the pre-dam surface and the sediment volumes stored in the reservoirs should be reduced for future analyses so that the sediment impacts can be determined more accurately. The timing of dam removal is dependent upon the duration of sediment impacts, which in turn is dependent upon the volume of stored sediment. Currently, GEC is taking a conservative approach to estimate sediment volumes, but the Team believes GEC is not taking a conservative approach in estimating the duration of elevated sediment concentrations downstream. It is uncertain if their final estimate of downstream sediment impacts is accurate or conservative. The team believes that reducing the uncertainty in the volume of sediment and pre-dam surface would cost a relatively small amount and improve the ability to estimate sediment impacts and plan dam removal schedules and mitigations.

The GEC report assumes that water quality impacts will be primarily isolated to the reservoir drawdown period. The only additional erosion of reservoir material is assumed by GEC to occur during subsequent high flow events with already high sediment concentrations. However, the sediment concentrations may be higher than background concentrations for a longer period of time due to continued sloughing of material into the channel. Associated water quality concerns must be addressed and quantified before the final costs of dam removal can be determined. Although there will be long-term improvements to water quality as the result of dam removal, the temporary (short-term) increases in suspended sediment and nutrient loads need to be quantified. None of these water quality concerns was fully addressed in the GEC report. The reports to date have not quantified uncertainties associated with the sediment impacts.

The GEC report also assumes that all four reservoirs will be drawn down simultaneously. This would likely result in the shortest duration of suspended sediment impacts. However, simultaneous drawdown may not be possible due to construction, budgetary, water quality, or other constraints not considered in the GEC study.

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[2] Feasibility-level designs and cost estimates are based on information and data obtained during pre-authorization investigations. These investigations provide sufficient information to permit the preparation of preliminary layouts and designs from which feasibility-level quantities for each kind, type, or class of material, equipment, or labor may be obtained. Feasibility-level cost estimates are used to assist in the selection of a preferred plan, to determine the economic feasibility of a project, and to support seeking project authorization.

Potential mitigation measures for downstream water users are identified by GEC; however, additional analyses should be performed to determine if the mitigation measures are sufficient. The proposed mitigation costs for water quality impacts ($1.6 million) are significantly lower than for similarly-sized dam removal projects, but they may be reasonable as none of the available water rights records indicate surface water diversion for domestic water supplies or industrial processes. Most downstream water use is for irrigation purposes. It should be noted, however, that downstream water users have not been contacted to determine whether the mitigations are acceptable and there may be some uncertainty in the assumed costs.

In summary, most assumptions and analyses included in the GEC report are reasonable, and based on the time, available data, and monetary constraints of the work, were all that could be accomplished for this level of study. However, additional work remains to be done to fully address the potential impacts of dam removal. The work completed by GEC is sufficient to suggest that the project is feasible and that the potential impacts of removing all four dams may be manageable. Project costs for removal of each of the four dams are summarized in Table 1 below for both the FERC Staff and GEC estimates, as provided by the Final EIS. The Team's preliminary review of the GEC report suggests that the overall costs estimated by GEC for dam removal and for environmental mitigation are probably low, although independent cost estimates have not been prepared for this review. No evaluation of the FERC Staff estimates has been made. The Team's recommendations for feasibility-level designs are included at the end of this report.

Table 1. – Cost Estimate Comparison in Millions of Dollars (2006)

Dam	FERC Staff Estimate[3]	GEC Estimate
Copco No. 1	20.4	22.5
Iron Gate	36.9	48.1
Subtotal – 2 dam removal	57.3	70.6
J.C. Boyle	18.9	14.5
Copco No. 2	3.7	4.7
Subtotal – 4 dam removal	79.9	89.8

Study Objectives and Background

The Klamath River flows from its headwaters near Crater Lake, Oregon, to its confluence with the Pacific Ocean in northern California. The Klamath Hydroelectric Project (Project) is owned by PacifiCorp, and includes four generating developments along the mainstem of the Upper Klamath River between river mile (RM) 190 and 228. The East Side and West Side Developments are located further upstream at Reclamation's Link River Dam at RM 254, and have been proposed by PacifiCorp for decommissioning. The Project also includes a re-regulation dam with no generation facilities (Keno Dam), and a

[3] Table 4-4 on Page 4-6 of the FEIS includes a third cost column labeled "**Reclamation Estimate (as presented by Ecotrust).**" Inclusion of this column is inappropriate, since no official cost estimate has been prepared by Reclamation for this project. The document referenced to by Ecotrust was likely the result of an informal review conducted by the Denver Technical Service Center of the Gathard 2003 report.

generating development on Fall Creek, a tributary to the Klamath River at RM 196. The installed generating capacity of the existing Project is 169 MW and, on average, the Project generates 716,800 MWh of electricity annually.

The Project is currently undergoing relicensing proceedings before the FERC. Separate from the formal FERC relicensing process, a Settlement Group has been exploring future project management alternatives to enhance fisheries, including dam removal alternatives. Previous dam removal studies (G&G Associates, 2003[4]) have suggested that downstream erosion of impounded sediment would be a feasible approach to dam removal and sediment management, but this conclusion was limited by the lack of information characterizing sediment quantity, quality, and management options. The State Coastal Conservancy (Conservancy) and the Ocean Protection Council (OPC), two agencies of the State of California, were requested by the Settlement Group's Dam Removal Subgroup to conduct a detailed reservoir sediment study and dam removal investigation. The Conservancy contracted with an A/E firm, Gathard Engineering Consulting (GEC), and with Shannon and Wilson, Inc. (S&W) to characterize the sediment impounded by the four lowermost dams on the Klamath River (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams), evaluate the potential downstream effects of reservoir sediment erosion, and to develop a feasible method of removing the four dams, including the preparation of cost estimates and construction schedules.

The GEC 2006 report was intended to provide an overview (or feasibility) analysis of dam removal and its effects on downstream water quality, and acknowledged that additional analyses would be required to fully evaluate dam removal as a preferred management alternative.

S&W sampled sediment and conducted other fieldwork necessary for completion of their study. Resulting analysis by GEC of the overall sediment volume (approximately 20.4 million yd^3), river morphology, and characteristics of the reservoir sediments indicated that approximately 4 million yd^3 of sediment would be eroded downstream due to the removal of the four dams. GEC estimated that 84 percent of the eroded sediment would remain in suspension in the river water, reaching the ocean within approximately four days. GEC assumed that all four reservoirs would be drawn down concurrently to reduce the overall duration of highly elevated total suspended sediment (TSS) levels in the river. GEC evaluated downstream suspended sediment concentrations assuming that the majority of the impounded sediments would be released over a period of 120 days (four months) beginning in October.[5] The estimated costs for removing the four dams, providing water quality protection and construction management, and developing engineering and permitting documents are approximately $88 million in the final (November 2006) GEC report (adjusted to $89.8 million in the Final EIS for inflation).

The four Klamath River dams are located downstream of Reclamation's project features associated with the Klamath Basin Project. Both Reclamation and the Department of the

[4] Prepared by Dennis Gathard, currently with GEC.
[5] A subsequent report, Gathard 2007, analyzed the difference between initiating reservoir drawdown in November or December as opposed to October.

Interior (Interior) therefore have a significant interest in the outcome of the various alternatives currently being discussed. Reclamation's Klamath Basin Area Office (KBAO) and Mid-Pacific (MP) Region, acting on behalf of Interior, requested the Technical Service Center (TSC) perform an in-depth review of the GEC study report, cost estimates, and associated appendices and technical memoranda, and prepare a report documenting the findings of the TSC Review Team (Team). This report provides an assessment of the overall design level of the study using Reclamation guidelines, and summarizes significant comments into recommendations. This report is intended to meet the requirements of the service agreement between KBAO and TSC.

The Team consisted of seven individuals with significant experience in concrete dams and appurtenant features, geotechnical engineering, mechanical engineering, electrical engineering, sediment management, construction, and cost estimating. Each individual also has experience with dam removal projects. The Team visited the Project between October 22 and 24, 2007, met with the A/E Consultant (GEC) and with representatives of the Conservancy and PacifiCorp, and was provided various reports and drawings for the review.

Prior to the completion of the Team's report, the Final Environmental Impact Statement (EIS) for the Klamath Hydroelectric Project (FERC No. 2082) was issued by FERC. The Final EIS contains Staff evaluations of the proposal submitted by PacifiCorp for continued operation of five of the six generating developments with new environmental measures, in addition to alternatives developed by the Staff for relicensing the Project. Project alternatives proposed in the Final EIS include the Staff Alternative, which incorporates most of PacifiCorp's proposed environmental measures with some modifications; the Staff Alternative with Mandatory Conditions, which requires the installation of fishways at each development; and two Staff dam removal alternatives, which include (1) the removal of Copco No. 1 and Iron Gate Dams, and the installation of fishways at Copco No. 2 Dam and J.C. Boyle Dam, and (2) the removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams. Both Staff dam removal alternatives assume that removal of Iron Gate Dam would not begin until about 5 years after issuance of a new project license, and the removal of upstream development(s) would be completed within about 3 years of license issuance. The basis for all dam removal cost estimates developed by FERC are described in the Final EIS, Section 4.7.

Project Descriptions (PacifiCorp, 2004a)

J.C. Boyle Dam

The J.C. Boyle Development consists of a reservoir, a combination embankment and concrete dam, a water conveyance system, and a powerhouse, located on the Klamath River between about RM 228 and RM 220, downstream of Keno Dam and upstream of Copco No. 1 Dam. J.C. Boyle Dam was completed in 1958 at RM 224.7. The purpose of the facility is to generate hydroelectric power.

J.C. Boyle Dam impounds a narrow reservoir of 420 surface acres (J.C. Boyle Reservoir). The normal maximum and minimum operating levels are between reservoir water surface

(RWS) elevations 3793 and 3788, a range of 5 feet. The reservoir contains approximately 3,495 acre-feet of total storage capacity, including 1,724 acre-feet of active storage capacity.

The embankment dam is a 68-foot-tall (at its maximum height above the original streambed) earthfill structure with a 15-foot-wide crest and a length of 413.5 feet at elevation 3800.0. The concrete portion of the dam is 279 feet long and is composed of a spillway section, an intake structure, and a 115-foot-long gravity section with a maximum height of 23 feet between the intake block and the left abutment.

The spillway is a concrete gravity overflow section with three 36-foot-wide by 12-foot-high radial gates. The spillway crest is at elevation 3781.5 and normal pool is 0.5 feet below the top of the gates (elevation 3793.5). The spillway bay discharges onto a 13-foot-long concrete apron stepped at three elevations generally following the profile of the bedrock surface. Below the apron is a vertical drop of 15 feet to the discharge channel, which was excavated in rock. The discharge channel is generally unlined. The estimated spillway discharge capacity at RWS elevation 3793 with all three gates open is 14,850 ft^3/s.

The intake structure is located to the left of the spillway and consists of a 40-foot-high reinforced concrete tower. It has four 11-foot, 2-inch-wide openings to the reservoir, each of which has a steel trash rack followed by a vertical traveling screen (0.25-inch mesh) with high pressure spray cleaners. Spray water along with any screened fish are collected and diverted downstream of the dam. A 24-inch-diameter fish screen bypass pipe provides approximately 20 ft^3/s of instream flow below the dam. A fabricated metal building was added to the intake structure in 1989. Beyond the intake traveling screens is an entrance to the 14-foot-diameter steel pipeline, the downstream end of which is equipped with a 14- by 14-foot automated fixed-wheel gate within a concrete headgate structure. A bulkhead gate is provided at the upstream end of the 14-foot pipeline.

A pool and weir concrete fish ladder is located at the dam for upstream fish passage and is approximately 569 feet long with a total of 63 pools. The fishway operates over a gross head range of approximately 55 to 60 feet.

The water conveyance system between the dam and the powerhouse has a total length of 2.56 miles. From the intake structure, the water flows through a 638-foot long, 14-foot-diameter steel pipeline. The pipeline is supported on steel frames where it spans the Klamath River and discharges into an open power canal. The power canal is 2 miles long and located along a bench cut in the face of the river canyon. Depending on the terrain, the canal is either a double- or single-walled concrete flume approximately 17-feet wide and 12-feet high. The power canal is provided with overflow structures at the upstream and downstream ends and terminates in a forebay. The forebay overflow section is equipped with float-operated automatic spill gates, which release water during the hydraulic surge from the canal following any load rejection at the powerhouse. The released water discharges through a short, concrete-lined chute and returns to the bypass reach of the Klamath River. Water for power generation is drawn from the forebay through a 60-foot-wide and 17.9-foot-high trash rack with 2-inch bar spacing before entering a 15.5-foot-diameter, concrete-lined, horseshoe-section tunnel, which is 1,660 feet long. The last 57-foot length of the tunnel before the downstream portal is steel-lined with the liner bifurcating into two 10.5-foot-diameter steel penstocks. The bifurcation is encased in a concrete anchor block, and a steel surge tank is mounted on the thrust block. Descending to the powerhouse, the penstocks reduce in two steps to 9 feet in diameter. Each penstock is 956 feet in length and is supported by ring girders seated on concrete footings.

The conventional outdoor-type reinforced concrete powerhouse is located on the right bank of the river and approximately 4.3 river miles downstream of the dam. There are two vertical-Francis turbines with a total rated discharge of 2,850 ft^3/s, and with 440 feet of net head. The rated capacity of the Unit 1 turbine is 56.78 MW with a generator rating of 50.35 MW, and the rated capacity of the Unit 2 turbine is 47.63 MW with a generator rating of 48.45 MW. Two three-phase transformers step up the generator voltage for transmission interconnection. The power from the powerhouse is transmitted a very short distance to the J.C. Boyle substation. There is also a second line that pre-dates the substation. The 0.24-mile 69-kV transmission line (PacifiCorp Line No. 98) connects the plant to a tap point on PacifiCorp's Line No. 18, which is currently unenergized.

Copco No. 1 Dam

The Copco No. 1 Development consists of a reservoir, dam, spillway, intake, outlet works, and powerhouse, located on the Klamath River between approximately RM 204 and RM 198, near the Oregon-California border. Copco No. 1 Dam was constructed between 1911 and 1922 at RM 198.6, and is downstream of J.C. Boyle Dam and upstream of Copco No. 2 Dam. The purpose of the facility is to generate hydroelectric power.

The Copco No. 1 reservoir is approximately 1,000 surface acres and contains approximately 15,200 acre-feet of total storage capacity at RWS elevation 2607.5, including approximately 6,235 acre-feet of active storage capacity. The normal maximum and minimum operating levels are between RWS elevations 2607.5 and 2601.0, with a range of 6.5 feet.

The dam is a concrete gravity arch structure with a 492-foot radius at the upstream face. As originally designed, the spillway crest was approximately 115 feet above the original river bed. After construction began, the river gravel was found to be over 100 feet deep at the dam site, and was excavated and then backfilled with concrete, making the total height of the dam 230 feet, measured from the lowest depth of excavation to the spillway crest, and 250 feet to the top of the spillway deck. The crest length between the rock abutments is approximately 410 feet. The upstream face of the dam is vertical at the top, then battered at 1 horizontal to 15 vertical. The downstream face is stepped, with risers generally about 6 feet in height. The ogee-type spillway is located on the crest of the dam. It is divided into 13 bays controlled by 14- by 14-foot radial (Tainter) gates, with a spillway crest at elevation 2593.5. The normal operating reservoir water level is 1.5 feet below the top of the gates at RWS elevation 2606.0. The estimated spillway discharge capacity at water surface elevation 2607.5 with all 13 gates fully open is 36,764 ft^3/s. The normal tailwater is maintained at elevation 2483 by Copco No. 2 Dam located 0.3 miles downstream.

Two intake structures are located at approximately invert elevation 2575.0 in the dam near the right abutment, each containing four vertical lift gates. Two 10-foot-diameter (reducing to 8-foot-diameter) steel penstocks feed Unit No. 1 in the powerhouse, while a single, 14-foot-diameter (reducing to two 8-foot-diameter) steel penstock feeds Unit No. 2. Additional facilities were provided at the right intake structure for future expansion of the powerhouse. There are two side-by-side trash racks in front of each intake which measure 44 feet wide and 12.5 feet high, with bar spacings of 3 inches.

The low-level sluice outlet has been abandoned. A 16- by 18-foot tunnel was excavated through the left abutment for streamflow diversion during construction, but was later sealed by either a concrete plug or by placement of a concrete bulkhead at the upstream end. A gated concrete intake structure was provided upstream of the dam for flow regulation during construction, but no information on the structure was found in the records.

The Copco No. 1 powerhouse is a reinforced-concrete substructure with a concrete and steel superstructure located at the base of Copco No. 1 Dam on the right bank. The two turbines are double-runner, horizontal-Francis units, with a total rated discharge of 2,360 ft^3/s. There are no turbine bypass valves. The two turbines are each rated at 18,600 hp with a net head of 125 feet. The generators are rated at 12,500 kVA with a 0.8 power factor (10 MW). Unit 1 has three single-phase, 5,000-kVA, 2,300/72,000-V transformers to step-up the generator voltage for transmission interconnection. Unit 2 has three single-phase, 4,165-kVA, 2,300/72,000-V transformers to step up the generator voltage for transmission interconnection. Copco No. 1 plant has two associated 69-kV transmission lines. PacifiCorp Line No. 15 connects the Copco No. 1 switchyard to Copco No. 2, approximately 1.23 miles to the west. PacifiCorp Line Nos. 26-1 and 26-2, each approximately 0.07 mile in length, connect Copco No. 1 powerhouse to the Copco No. 1 switchyard.

Copco No. 2 Dam

The Copco No. 2 Development consists of a concrete diversion dam, a small impoundment, a water conveyance system, and a powerhouse. The dam was constructed in 1925 approximately 1/4 mile downstream of Copco No. 1 Dam at RM 198.3, while the powerhouse is located at RM 196.8. The purpose of the facility is to generate hydroelectric power.

The reservoir created by Copco No. 2 Dam is approximately 1/4-mile long and has a storage capacity of 73 acre-feet. At the normal RWS elevation 2483, there is very minimal active storage. Elevation 2483 is both the maximum and minimum normal RWS. As a result, Copco No. 2 generation tracks Copco No. 1 generation.

The dam is a concrete gravity structure with an intake to the water conveyance tunnel on the left abutment and a 145-foot-long spillway section with five radial (Tainter) gates. The dam is 33 feet high, has an overall crest length of 335 feet, and a crest width of 9 feet at elevation 2493. The dam has a 132-foot-long earthen embankment with a gunite cutoff wall on the right abutment. The dam has a manual gate controlling a sluiceway adjacent to the intake. A corrugated metal flume provides approximately 5 ft^3/s of instream flow in the bypass reach. The concrete gravity spillway crest is at elevation 2473. The estimated spillway discharge capacity at RWS elevation 2483 is 13,060 ft^3/s with the five gates fully open.

The intake structure incorporates trash racks and a roller-mounted (caterpillar) bulkhead gate. The trash rack is 36.5 feet by 48 feet and has a 2-inch bar spacing. The water conveyance system for the powerhouse includes 2,440 feet of concrete-lined tunnel, 1,313 feet of wood-stave pipeline, an additional 1,110 feet of concrete-lined tunnel, a surge tank, and two steel penstocks. The diameter of the tunnel and wood stave pipeline sections is 16 feet. The two penstocks, one 405.5 feet long and one 410.6 feet long, range from 16 feet in diameter at the inlet to 8 feet in diameter at the turbine spiral cases.

The powerhouse is a reinforced concrete structure that houses two vertical-Francis turbines with a total rated discharge capacity of 2,676 ft^3/s. Each turbine has a rated capacity of 20,000 hp at 140 feet of net head. The synchronous generators are rated at 15,000 kVA with a 0.9 power factor (13.5 MW). There are three single-phase, 10/20-megavolt ampere (MVA), 6,600/72,000-V transformers for each generator to step up the voltage. There are also three single-phase, 10/20-MVA, 73,800/230,000-V step-up transformers for interconnection to the transmission system. A 69-kV transmission line (PacifiCorp Line No. 15) connects the Copco No. 2 powerhouse to the Copco No. 1 switchyard, approximately 1.23 miles to the west.

Iron Gate Dam

The Iron Gate Development consists of a reservoir, an earth embankment dam, an ungated side-channel spillway, intakes for the diversion tunnel and penstock, a steel penstock from the dam to the powerhouse, and the powerhouse. It is located on the Klamath River between approximately RM 196.8 and RM 190, approximately 20 miles northeast of Yreka, California. The dam was completed in 1962 at RM 190.1. It is the farthest downstream hydroelectric facility of the Klamath Hydroelectric Project. The purpose of the Iron Gate facilities is to generate hydroelectric power.

The reservoir formed upstream of Iron Gate Dam is approximately 944 surface acres and contains approximately 58,794 acre-feet of total storage capacity at RWS elevation 2328.0, including 3,790 acre-feet of active storage capacity. The normal maximum and minimum operating levels are between RWS elevations 2328.0 and 2324.0, a range of 4 feet.

The dam is a zoned earthfill embankment with a height of 189 feet from the rock foundation to the dam crest at elevation 2343.0. The dam crest is 20 feet wide and approximately 740 feet long. It has a central, vertical-asymmetrical clay core. The dam is founded on a sound basalt rock foundation. There is a grout curtain in the bedrock beneath the impervious core. In 2003, modifications were made to Iron Gate Dam to raise the dam crest five feet from elevation 2343 to elevation 2348. This was accomplished by over steepening the upstream and downstream slopes and decreasing the crest width from 30 feet to 20 feet. A sheet pile wall was also driven along the centerline at the crest with three feet of stick up to provide freeboard, in addition to the 5-foot crest raise. Additional riprap materials were placed on the upstream face of the dam to protect those areas inundated by the higher reservoir elevations.

There are fish trapping and holding facilities located on the random fill area at the dam toe. The top of the random fill area is at elevation 2189.0. High- (elevation 2310) and low- (elevation 2250) level intakes for the fish facility water are incorporated in the dam.

The spillway is excavated in rock at the right abutment. It is an ungated chute spillway with a side channel entrance. The spillway crest is at elevation 2328.0, 15 feet below the dam crest. The spillway crest is 727 feet long and consists of a concrete ogee and slab placed over the excavated rock ridge. The upper part of the channel is partly lined with concrete. At the end of the chute, a flip-bucket terminal structure is located approximately 2,150 feet downstream of the toe of the dam. The spillway has a design discharge capacity of 32,000 ft^3/s at RWS elevation 2333.0. The modifications completed in 2003 included shotcrete protection at the top of the spillway crest and chute.

The diversion tunnel used during construction was driven through bedrock in the right abutment and is still in place. The tunnel terminates in a reinforced concrete outlet structure at the downstream toe of the dam. Control of the flow in the tunnel is provided by a slide gate approximately 112 feet upstream of the dam axis. The gate is housed in a reinforced concrete tower accessible by bridge from the dam crest. The intake is a reinforced concrete structure equipped with trash racks and is submerged on the floor of the reservoir approximately 380 feet upstream from the dam axis. Operation of the gate controlling flow through the tunnel is limited to emergency use during high flow events. If needed for such purposes, the tunnel can pass up to approximately 5,000 ft^3/s. The intake structure for the powerhouse is a 45-foot-high, free-standing, reinforced-concrete tower, located in the reservoir immediately upstream of the left dam abutment. It is accessed by a foot bridge from the abutment. It houses a 14- by 17-foot slide gate, which controls the flow into a 12-foot-diameter, welded-steel penstock. The penstock is concrete-encased where it penetrates the dam approximately 35 feet below the normal maximum reservoir level. The penstock is supported on concrete supports down the dam abutment. There is a 17.5- by 45-foot trash rack at the penstock entrance with a 4-inch bar spacing.

The powerhouse is located at the base of the dam on the left bank, and consists of a single vertical Francis turbine with a rated discharge capacity of 1,735 ft^3/s. In the event of a turbine shutdown, a synchronized Howell-Bunger bypass valve located immediately upstream of the turbine diverts water around the turbine to maintain flows downstream of the dam. The turbine has a rated output of 25,000 hp at a rated net head of 154 feet. The synchronous generator is rated 18.947 kVA with a 0.95 power factor (18 MW). There is a single three-phase, 18,947-kVA, 6,600/69,000-V step-up transformer at the powerhouse to interconnect the PacifiCorp transmission system. The Iron Gate powerplant has one associated 69-kV transmission line. Line No. 62 runs along the north side of Iron Gate reservoir for approximately 6.55 miles, to the Copco No. 2 switchyard.

The Iron Gate fish hatchery was constructed in 1966 and is located downstream of Iron Gate Dam, adjacent to the Bogus Creek tributary. The hatchery complex includes an office, incubator building, rearing ponds, fish ladder with trap, visitor information center, and employee residences. Up to 50 ft^3/s is diverted from the Iron Gate reservoir to supply the 32 raceways and fish ladder. The hatchery produces Chinook salmon, steelhead trout, and Coho salmon. Annual production goals are 6 million Chinook, 200,000 steelhead, and 75,000 Coho. The hatchery is operated by the California Department of Fish and Game. Eighty percent of operations and maintenance costs are funded by PacifiCorp.

Civil Engineering Review of Dam Removal Plans

J.C. Boyle Dam

GEC has assumed that the reservoir would be drawn down for dam removal to approximately RWS elevation 3780 (or below the existing spillway crest) through the existing 14-foot-diameter pipeline. Additional drawdown to approximately RWS elevation 3762 was assumed to require the use of two existing 10- by 9.5-foot concrete culverts located near the bottom of the concrete overflow section and originally used to divert river flows during construction. It is unclear to the Team whether or not these culverts will actually be available for use during dam removal; however, GEC assumes that concrete stoplogs placed at the upstream intake of each culvert can be removed by a mobile crane to permit downstream releases. If this proves not to be the case, the dam removal cost would be higher. Additional reservoir drawdown would be achieved by natural erosion of the embankment section and impounded sediments to the original streambed level, to permit removal of the concrete dam and appurtenant structures in the dry. The normal downstream tailwater level for the dam is approximately elevation 3730. The upstream toe of the dam is estimated to be at elevation 3740. Much of the reservoir between RWS elevations 3740 and 3762 is filled with sediment. Bedrock along the dam axis is a hard, fine-grained basalt.

The proposed removal limits for the concrete dam and appurtenant structures are not clearly stated in the GEC report; however, GEC probably assumed that the concrete structures would be removed where exposed. GEC included items in the cost estimate for demolition or removal of most of the major structural features. Possible exceptions include the power canal floor and inner wall, the power canal spillway structure and concrete-lined chute (or forebay overflow section), and the tunnel portal structures. The Final EIS includes the removal of these features, as well as the plugging of the tunnel portals and backfilling of the canal site and tailrace area, for the dam removal options. However, if the canal site is to be backfilled and regraded to restore the area, removal of the canal floor and inner wall may not be necessary.

Extensive headcutting erosion has occurred within the forebay overflow section discharge channel since construction, and the Final EIS indicates that this channel will be backfilled and stabilized to restore the preconstruction slope on the right bank of the river channel following dam removal. This would require a large quantity of material to complete, and is not included in the GEC estimate. The Final EIS also assumes that the powerhouse substructure and switchyard would be retained, while the GEC plan included their removal, but at a very low cost. Retention of any structures would involve long-term maintenance costs.

Quantity estimates (by weight or volume) are included in the GEC report for only a portion of the removal items, while the others are listed as lump sum. No quantity estimates were checked by the Team for this review. However, GEC apparently did not have access to all currently available information for the dam, and had to make assumptions for many of the quantity estimates. The quantity estimates therefore have to be considered no better than appraisal-level, and do not necessarily match the assumptions made for the Final EIS. Waste disposal sites for the left abutment structures also need to be identified for estimating haul distances, as transporting concrete debris across the river after the embankment has been breached would be more difficult. A cost for hydroseeding 300 acres within the reservoir area was included by GEC for site restoration, although not assumed for the Final EIS, but is probably prudent at this level of design.

A comparison of the structure removal requirements for J.C. Boyle Dam and Powerhouse adopted for the Final EIS Staff dam removal options and for the GEC report is provided in Table 2. A final determination of removal limits should be made for feasibility design.

Table 2 – J.C. Boyle Dam and Powerhouse, Removal Requirements

Feature	**Final EIS**	**GEC Report**
Embankment Dam	Remove	Remove, Erode
Power Conveyance Intake	Remove	Remove
Spillway Tainter Gates, Structure	Remove	Remove
Fish Ladder	Remove	Remove
Steel Pipeline and Supports	Remove	Remove
Canal Intake (Screen) Structure	Remove	Remove
Canal Flume	Remove	Remove outer wall
Canal Spillway	Remove	
Tunnel Entrance Structure	Remove	
Penstocks, Supports, Anchors	Remove	Remove
Tunnel Portals	Seal	
Powerhouse Crane	Dismantle/Remove	
Powerhouse Substructure/Slab (doors, windows, roof, draft tubes)	Retain, Seal Openings	Remove
Powerhouse Timber, Equipment	Remove	Remove
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	

Feature	Final EIS	GEC Report
Tailrace Flume Walls	Retain, Bury	
Dam Abutments	Regrade, Vegetate	
Tailrace Channel Area	Backfill, Regrade	
Canal Spillway Channel Area	Backfill, Regrade	
69-kV Transmission Line, 0.24 mi	Remove	
Transmission Line ROW	Restore	
Switchyard	Retain	Remove
Warehouse, Support Buildings	Remove	
Reservoir area		Vegetate

Copco No. 1 Dam

Reservoir drawdown for dam removal is currently limited by the discharge capacity of the penstocks to approximately RWS elevation 2585. Inspection records indicate a 16- by 18-foot excavated tunnel was originally used to divert the river through the left abutment for construction of the dam, but was reportedly sealed by a concrete bulkhead or plug at the upstream end. The GEC report refers to a 6-foot-diameter diversion tunnel (apparently by mistake) and indicates that this tunnel, even if it could be reopened, may be too small for effective reservoir drawdown during the late fall through early winter months. Regardless, insufficient information was found on the existing discharge capacity of the diversion tunnel and gated intake structure, and additional study is needed. Use of the existing diversion tunnel for reservoir drawdown may be more economical than other alternatives. The Final EIS assumes that this tunnel could be used for reservoir drawdown, but increased the contingency allowance from 25 to 50 percent in case another method is required. In lieu of reopening the existing diversion tunnel, GEC proposed three alternatives for reservoir drawdown: (1) notching the concrete dam crest in stages, (2) constructing a large diameter gated outlet through the base of the concrete dam, and (3) constructing a series of smaller diameter ungated outlets at various elevations through the concrete dam. The low-level gated outlet alternative was selected by GEC for project scheduling and cost estimating, with an assumed (average) reservoir drawdown rate of 1 foot per day between RWS elevations 2585 and 2480. The Team believes that the underwater installation of a single slide gate at the upstream face, with excavation upstream to the gate, may be preferable to the proposed downstream roller gate location. However, notching the concrete dam crest for drawdown in stages has been assumed previously by Reclamation for removal of Glines Canyon Dam on the Elwha River in Washington, having a similar annual average flow, and may be more economical than constructing one or more new outlets through the dam. Any drawdown alternative selected would have to consider the discharge capacity required for the anticipated reservoir inflow, and the acceptable drawdown rate.

GEC assumed that dam removal would be performed using conventional drilling and blasting methods, and would be completed to 5 feet below the predam riverbed level during the low flow period (August or September). Much of the foundation concrete below the riverbed would remain in place. The Team found inspection records which indicate the dam was constructed with large (cyclopean) boulders placed in the concrete matrix, and reinforced throughout with 465 tons of 30 pound steel rails, placed in horizontal mats and in vertical rows across construction joints, which will complicate demolition activities. GEC assumed that a large tower crane would be used on the right abutment intake structure to remove the concrete rubble and reinforcing steel from the dam. GEC assumed the reinforcing steel would be recycled, and the concrete rubble would be wasted on the right abutment within an assumed on-site disposal area. GEC included items in the cost estimate for removal of the spillway gates, intake structure, penstocks, powerhouse, and substation. The Final EIS assumes that the intake structure and powerhouse would be retained on the right side of the river (following the removal of any hazardous materials and the sealing of any openings) to reduce demolition costs under the dam removal options. Retention of any structures would involve long-term maintenance costs.

Quantity estimates (by weight or volume) are included in the GEC report for only a portion of the removal items, while the others are listed as lump sum. No quantity estimates were checked by the Team for this review. However, GEC apparently did not have access to all currently available information for the dam, and had to make assumptions for many of the quantity estimates. The quantity estimates therefore have to be considered no better than appraisal-level. A cost for hydroseeding 800 acres within the reservoir area was estimated by GEC for site restoration (not assumed for the Final EIS, but probably prudent), and an allowance for environmental cleanup was included.

A comparison of the structure removal requirements for Copco No. 1 Dam and Powerhouse adopted for the Final EIS Staff dam removal options and for the GEC report is provided in Table 3. A final determination of removal limits should be made for feasibility design.

Table 3 – Copco No. 1 Dam and Powerhouse, Removal Requirements

Feature	**Final EIS**	**GEC Report**
Concrete Dam and Spillway Gates	Remove above channel, Retain below channel	Remove to 5 feet below channel
Penstocks	Remove	Remove
Powerhouse Intake Structure Foundation and Gatehouse	Retain, Seal Openings	Remove
Tunnel Intake and Gate Structure	Remove	Remove
Tunnel Portals	Seal	Seal
Powerhouse (doors, windows, penstock, draft tubes)	Retain, Seal Openings	Remove
Powerhouse Timber, Equipment	Remove	Remove
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
Two 69-kV Transmission Lines, 0.7 mi	Remove	
Transmission Line ROW	Restore	
Switchyard	Remove, Restore	Remove
Reservoir Area		Vegetate

Copco No. 2 Dam

Copco No. 2 Dam is located between Copco No. 1 Dam and Iron Gate Dam, and impounds only 73 acre-feet of water. For dam removal, GEC proposes to utilize the storage capacities of the upstream and downstream reservoirs to temporarily dry up the river reach at Copco No. 2 Dam to remove the concrete spillway structure in the dry, using conventional drilling and blasting methods. The Team assumes that minimum streamflow releases of 5 to 10 ft^3/s could be maintained through the reach if necessary without significant impacts to the demolition activities. Alternatively, GEC indicates a cofferdam could be constructed within the river channel to divert larger flows into the water conveyance system for the powerhouse, to permit removal of the spillway. GEC assumes that concrete rubble would be hauled to a nearby disposal site, and the deep concrete cutoff walls below the river channel grade would be retained. Following restoration of the river channel through the spillway site, the remaining features could be removed, including the tunnel intake structure on the left abutment and the earth embankment on the right abutment. The tunnel portals would be permanently sealed, and the wood-stave pipeline located between the two tunnels, as well as the downstream penstocks to the powerhouse, would be removed, although the total length of the pipelines (2,130 feet) is far less than the quantity assumed by GEC (1,000 feet). GEC also included items in the cost estimate for removal of the Copco No. 2 powerhouse and substation (including an allowance for environmental cleanup), and for backfilling the canal (tailrace) channel to the Klamath River. However, the Final EIS assumes that the powerhouse and substation (or switchyard) would be retained (following the removal of any hazardous materials and the sealing of any openings) to reduce demolition costs, but does not indicate whether the tailrace channel is to be backfilled.

Quantity estimates (by weight or volume) are included in the GEC report for only a portion of the removal items, while the others are listed as lump sum. No quantity estimates were checked by the Team for this review. However, GEC apparently did not have access to all currently available information for the dam, and had to make assumptions for many of the quantity estimates. As indicated above, the total length of pipelines assumed by GEC is far below the actual quantity. The quantity estimates therefore have to be considered no better than appraisal-level.

A comparison of the structure removal requirements for Copco No. 2 Dam and Powerhouse adopted for the Final EIS Staff dam removal options and for the GEC report is provided in Table 4. A final determination of removal limits should be made for feasibility design.

Table 4 – Copco No. 2 Dam and Powerhouse, Removal Requirements

Feature	**Final EIS**	**GEC Report**
Spillway Tainter Gates, Structure	Remove	Remove
Tunnel Intake Structure	Remove, Backfill	Remove
Tunnel Portals	Seal	Seal
Dam Abutments	Regrade, Vegetate	Remove
Penstock, Supports, Anchors	Remove	Remove

Feature	Final EIS	GEC Report
Powerhouse (doors, windows, penstock, draft tubes)	Retain, Seal Openings	Remove
Powerhouse Timber, Equipment	Remove	Remove
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
69-kV Transmission Line, 1.23 mi	Remove	
Transmission Line ROW	Restore	
Switchyard	Retain	Remove
Tailrace Channel		Backfill

Iron Gate Dam

GEC has assumed that the reservoir would be drawn down for dam removal from RWS elevation 2325 to approximately RWS elevation 2200 using the existing gated diversion tunnel through the right abutment. This tunnel has been modified recently by PacifiCorp to improve discharge capacity, which is not reflected in the GEC report. The reservoir level must be maintained below the elevation of the excavation until the embankment and downstream facilities have been removed. A significant work effort has been assumed to complete the excavation of the embankment within a period of approximately 4 months (June through September). GEC has proposed the construction of new downstream gate facilities and a tunnel liner to ensure adequate discharge capacity during reservoir drawdown for a total estimated cost of $2 million; however, the recently completed tunnel modifications should provide adequate flow control for this purpose.

GEC would allow the concrete-lined side-channel spillway, chute, and flip-bucket terminal structure to remain and be filled with up to 300,000 yd^3 of excavated embankment material, which the Team believes to be appropriate. Existing structures to be removed either during or before reservoir drawdown include the fish collection and power generation facilities at the downstream toe, the power penstock, the water supply pipes, and the penstock intake structure. Following excavation of the earth embankment, the concrete cutoff wall and diversion tunnel intake structure would be removed and the tunnel portals would be sealed with concrete. A cost for revegetation and hydroseeding 800 acres within the reservoir area was estimated by GEC for site restoration (not assumed for the Final EIS, but prudent for this study), and an allowance for environmental cleanup was included. An alternative water source would have to be found for the fish hatchery to remain operational. The GEC estimate included a substantial water quality protection allowance for construction of a new fish hatchery ($7.5 million). The existing hatchery was originally constructed as mitigation for Iron Gate Dam, and the Final EIS did not consider this to be a project requirement.

Quantity estimates (by weight or volume) are included in the GEC report for only a portion of the removal items, while the others are listed as lump sum. No quantity estimates were checked by the Team for this review. However, GEC apparently did not have access to all currently available information for the dam, and had to make assumptions for many of the quantity estimates. The quantity estimates therefore have to be considered no better than appraisal-level.

A comparison of the structure removal requirements for Iron Gate Dam and Powerhouse adopted for the Final EIS Staff dam removal options and for the GEC report is provided in Table 5. A final determination of removal limits should be made for feasibility design.

Table 5 – Iron Gate Dam and Powerhouse, Removal Requirements

Feature	**Final EIS**	**GEC Report**
Embankment Dam	Remove	Remove
Penstock Intake Structure	Remove	Remove
Penstock	Remove	Remove
Water Supply Pipes	Remove	Remove
Spillway Structure	Retain, Bury	Retain, Bury
Powerhouse Crane	Dismantle, Remove	Remove
Powerhouse Timber, Equipment	Remove	Salvage
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
Powerhouse Substructure	Remove above lowest Slab	Remove
Powerhouse Tailrace Area	Backfill, Regrade	
Fish Facilities on Dam	Remove	Remove
Fish Hatchery	Retain (Needs Water)	Replace
Switchyard	Remove, Restore	Remove
69-kV Transmission Line, 6.55 mi	Remove	
Transmission Line ROW	Restore	
Diversion Tunnel Intake Structure		Remove
Diversion Tunnel Portals		Seal
Diversion Tunnel Control Gate		Furnish and Install, Remove
Concrete Cutoff Wall		Remove
Reservoir Area		Vegetate

Geotechnical Review of Dam Removal Plans

J.C. Boyle Dam

J.C. Boyle Dam was constructed in 1958 and is a zoned earthfill dam with central clay core and upstream and downstream shells composed of sand and gravel. The structural height of the dam is 68 feet with a crest at elevation 3800.0. The crest width is 15 feet and the crest length is 693 feet. Total volume of the embankment was estimated by GEC at about 125,000 yd^3. Reservoir storage capacity is 3,495 acre-ft at the normal RWS elevation 3793.0.

The GEC estimate for removal of J.C. Boyle Dam required many assumptions due to the limited available data and the uncertainty regarding the overall timing of events in the removal of the four dams and the associated structures. Some of the areas of uncertainty with regard to the dam removal include: reservoir drawdown rate, time period during which the embankment and associated structures will be removed, and the size of flood to design for during embankment removal.

The GEC report represents a reasonable effort at developing a method and cost of removal when considering the uncertainties remaining at this time with regard to the removal process. These uncertainties, of course, have an impact on the accuracy of the cost estimate.

Because there are no structures around the reservoir rim that could be damaged by slope failures, the GEC report indicates drawdown of J.C. Boyle Reservoir would be controlled by the rate that would be safe for the dam. A drawdown rate of 1 ft/day is common and would be unlikely to cause a rapid drawdown failure especially since the embankment shells are a mixture of sand and gravel which should have a high strength. However, no analysis has been provided to verify stability for this drawdown rate. From the normal RWS (elevation 3793) to the invert of the steel canal conduit (elevation 3780), the reservoir drawdown rate can be controlled. However, it is not clear how much control there is on the drawdown rate from the invert of the steel conduit to the invert of the dual concrete culverts (elevation 3762). For the short interval from RWS elevation 3780 to 3762, the Team believes that a drawdown rate of more than 1 ft/day would most likely be acceptable if the drawdown rate from RWS elevation 3793 to 3780 is held to 1 ft/day. Prior to embankment removal, the preferred drawdown sequence should be determined and a stability analysis should be performed to verify stability.

GEC has assumed that reservoir rim stability is not an issue for removal of J.C. Boyle Dam because there are no structures around the reservoir except for the highway bridge. An evaluation of the slopes around the reservoir rim should still be performed to determine whether there is any history of large landslides in the geologic units that exist in the reservoir.

Freeboard would have to be maintained between the elevation of the excavated embankment surface and the reservoir to prevent flood overtopping and potential embankment failure. The freeboard would be dictated by the amount of flood protection that is desired (in terms of flood return period) during the removal operation.

Once the reservoir has been lowered to RWS elevation 3762 and the embankment has been removed to approximately that same elevation, the GEC removal plan calls for the natural flow of the river to erode the remaining embankment and upstream sediments. The Team believes that the embankment will provide more resistance to erosion than the upstream sediment, in which case it may take longer than anticipated to release the sediment. It may therefore be desirable to excavate a channel through the remaining embankment. This would create a concentrated flow of the river and would hopefully accelerate the erosion of the dam.

Other general observations of the Team that would impact the dam removal operations are listed below:

- There is little information on many of the lump sum items in the GEC cost estimate which makes an evaluation of those estimates difficult. There is often a tendency for these costs to go up when more detailed cost estimates are performed.

- The dam removal plan as presented in the GEC report calls for compaction of the embankment materials when placed in the waste area. As long as there are no plans to build structures on this material compaction would not be necessary.

Iron Gate Dam

Iron Gate Dam was constructed between 1960 and 1962 and is a zoned earth and rockfill dam with a structural height of 189 feet and a crest at elevation 2343.0. The crest width is 20 feet and the crest length is 740 feet. The total volume of the embankment was estimated by GEC at about 1.1 million yd^3.

The diversion tunnel through the rock in the right abutment remains from the original construction and will be used to drain the reservoir and divert the river flows while the embankment is being removed.

The GEC estimate for removal of Iron Gate Dam required many assumptions due to the limited available data and the uncertainty regarding the overall timing of events in the removal of the four dams and the associated structures. Some of the areas of uncertainty with regard to the dam removal include: spoil location for embankment materials, reservoir drawdown rate, time period during which the embankment and associated structures will be removed, the size of flood to design for to minimize overtopping during dam removal, and the amount of modification required on the diversion tunnel gate to control flows.

The GEC report represents a reasonable effort at developing a method and cost of removal when considering the uncertainties remaining at this time with regard to the removal process. These uncertainties, of course, have an impact on the accuracy of the cost estimate.

High river flows typically end in mid-April at which time GEC has assumed that the drawdown process could start. If the reservoir is full in mid-April the total drawdown to the invert of the diversion tunnel would be 150 feet (from RWS elevation 2325 to RWS elevation 2175). The GEC report assumed a drawdown of 1 ft/day, but suggested that a faster drawdown rate (up to 3 ft/day) may be acceptable. At 1 ft/day, the drawdown would take 5 months. However, embankment removal could start shortly after the reservoir drawdown is initiated. Freeboard would have to be maintained between the elevation of the excavated embankment surface and the RWS. This freeboard would be dictated by the amount of flood protection that is desired (in terms of flood return period) during the dam removal operations. Normally when the dam is higher and failure due to flood overtopping would cause a catastrophic release of reservoir water, the flood storage (freeboard) has to be larger. As dam removal nears completion and the reservoir impoundment is much smaller, the consequences of overtopping are not as great and less freeboard would be acceptable.

Increasing the drawdown rate beyond 1 ft/day would provide increased flexibility in the removal schedule because less time would be required for reservoir drawdown. The Team believes that a drawdown rate of 1 ft/day is very common and should not impact stability of Iron Gate Dam because the dam has wide pervious outer zones (Zones 1 and 2) that not only have high strength, but should also drain relatively fast as the reservoir is drawn down. However, 3 ft/day would be an unusual drawdown rate for the entire 150 feet of reservoir drawdown, although the GEC report provided analysis indicating this rate would be acceptable. This might be the case due to the nature of Zones 1 and 2. However, the Team did not evaluate the GEC reservoir drawdown analysis as part of this review, and additional study would be recommended before the 3 ft/day drawdown rate could be recommended. One option could be to draw the reservoir down faster at the beginning of the drawdown process and reduce the rate as the reservoir level decreases. The upper part of the embankment has less volume per foot of height than the lower embankment and could be excavated faster which might be a reason to have a faster drawdown rate for the upper part of the reservoir. In any case, drawdown rates that exceed 1 ft/day should be studied in more detail before being adopted.

The natural slopes on the reservoir rim usually control the allowable drawdown rate because natural slopes in soil are often not as stable as the engineered slopes of an embankment. A cursory review of the reservoir rim at Iron Gate Dam did not reveal obvious stability problems. Typically rapid drawdown failures are shallow slides that do not have significant impact. In addition, the Iron Gate Reservoir rim does not appear to have significant structures that would be impacted by rapid drawdown slope failures. A rate of 1 ft/day is not unusual for reservoir drawdown. However, as more detailed dam removal plans are developed, additional evaluation of the reservoir rim should be performed to determine the potential for large landslides. Reclamation would generally not recommend a drawdown rate of 3 ft/day without a much more detailed evaluation of the reservoir rim slopes. Faster drawdown rates could result in deeper slides which present a greater safety concern due either to the slide or the potential for reservoir waves generated by the slide.

The diversion scheme developed by GEC includes a sheet pile cofferdam in the final stage of the dam removal. There is a good possibility that the sheet pile will be difficult to drive due to oversized materials that likely exist in the fill at the toes of the dam, and an alternative scheme may be required. The final underwater remnant of the cofferdam may have to be excavated by clam shell or dragline.

Other general observations of the Team that would impact the dam removal operations are listed below:

- During the Team's site visit in October, the morning fog was very thick until 10 am. If this were to occur during dam removal, it could impact the rate at which trucks can haul the excavated embankment materials to the waste area because of reduced visibility on the haul road.

- There is little information on many of the lump sum items in the cost estimate which makes an evaluation of those estimates difficult. There is often a tendency for these costs to go up when more detailed cost estimates are performed.

- The dam removal plan as presented in the GEC report calls for compaction of the embankment materials when placed in the waste area. As long as there are no plans to build structures on this material compaction would not be necessary.

- Removal of the riprap before the rest of the dam is excavated will be difficult and most likely more expensive than removal when the rest of the dam is excavated.

Mechanical Engineering Review of Dam Removal Plans

J.C. Boyle Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse and generation facilities at J.C. Boyle Dam ($150,000) which is considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and removal of the structure itself. If the intent was to demolish the entire power plant, the following major mechanical equipment would need to be removed from the plant and trucked off site: two vertical Francis hydraulic turbine units (Unit 1 – 63,900 HP, Unit 2 – 75,700 HP), two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two turbine runner spiral casings and head covers/operating rings, four turbine gate hydraulic servomotors, two vertical turbine shafts, two 9.5-foot-diameter turbine penstock pipes from intake structure to powerhouse, a 30-foot-diameter by 78-foot-high surge tank, two turbine draft tubes, two 4-foot-diameter fixed-cone synchronous bypass valves with hydraulic operators, an electric oil pump and sump tank, 48-inch-diameter bypass piping off penstocks around left side of powerhouse, draft tube bulkhead gate, plant vertical sump pumps, bearing oil storage tank(s), generator outdoor gantry crane and associated structural support members, and other miscellaneous mechanical equipment, piping, and valves. The mechanical equipment removal costs alone would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Although there were no known hazardous materials identified at the time of the Team's site visit, there may be asbestos, bearing and hydraulic control system oils, PCB's, or coatings containing heavy metals in the plant and on the exterior surfaces of the outside steel penstock pipes, surge tank, bulkhead gate, and generator gantry crane which would need specialized abatement requirements.

The Staff dam removal options in the Final EIS report assumed that the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, mechanical equipment could be left in place with all power connections to the outside removed. Any oil in the turbine governor and fixed-cone bypass valve hydraulic control systems, oil storage tanks, or other equipment would still need to be removed. The generator overhead gantry crane at this plant is outdoor equipment which may be viewed as unsightly or a potential hazard to people. If the crane were to be removed, then all equipment would need to be hauled off the project site and the units would have to be disassembled in several sections prior to being trucked off site.

Copco No. 1 Dam and Powerhouse

The GEC report identified a single lump sum pay item to demolish the powerhouse structure at Copco No. 1 Dam ($275,000) which is considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and removal of the structure itself. If the intent was to demolish the entire power plant, the following major mechanical equipment would need to be removed from the plant and trucked off site: two horizontal Francis hydraulic turbine units with two runners per turbine (Unit 1 – 21,800 HP, Unit 2 – 18,600 HP), four turbine runner spiral casings and head covers/operating rings, two horizontal turbine shafts, two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two 10-foot-diameter (reducing to two 8-foot-diameter) and one 14-foot-diameter (reducing to two 8-foot-dimaeter) turbine penstock pipes from intake structure to powerhouse, three penstock vertical air vent pipes, two turbine draft tubes, draft tube bulkhead gate(s), plant vertical sump pump(s), bearing oil storage tank(s), one 40-ton and one 15-ton overhead traveling cranes and structural members, and other miscellaneous mechanical equipment, piping, and valves. The mechanical equipment removal costs would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Although there were no known hazardous materials identified at the time of the Team's site visit, there may be asbestos, bearing and governor hydraulic oils, PCB's, or coatings containing heavy metals in the plant and on the exterior surfaces of the outside steel penstock pipes, surge tank, bulkhead gate, and crane which would need specialized abatement requirements.

The Staff dam removal options in the Final EIS report assumed that the Powerhouse structure did not need to removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, mechanical equipment could be left in place with all power connections to the outside removed. Any oil in the turbine governor hydraulic control systems, oil storage tanks, or other equipment would still need to be removed.

Copco No. 2 Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse facilities at Copco No. 2 Dam ($150,000) which is considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and removal of the structure itself. If the intent was to demolish the entire power plant, the following major mechanical equipment would need to be removed from the plant and trucked off site: two vertical Francis hydraulic turbine units (Unit 1 – 26,300 HP, Unit 2 – 20,000 HP), two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two turbine runner spiral casings and head covers/operating rings, four turbine gate hydraulic servomotors, two vertical turbine shafts, two 16-foot-diameter (reducing to 8-foot-diameter) turbine penstock pipes from intake structure to powerhouse, two penstock vertical air vent pipes, two turbine draft tubes, draft tube bulkhead gate(s), plant vertical sump pump(s), bearing oil storage tank(s), overhead traveling crane and structural members, and other miscellaneous mechanical equipment, piping, and valves. The mechanical equipment removal costs would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Although there were no known hazardous materials identified at the time of the Team's site visit, there may be asbestos, bearing and governor hydraulic oils, PCB's, or coatings containing heavy metals in the plant and on the exterior surfaces of the outside steel penstock pipes, penstock vertical air vent pipes, and bulkhead gate(s) which would need specialized abatement requirements.

The Staff dam removal options in the Final EIS report assumed that the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, mechanical equipment could be left in place with all power connections to the outside removed. Any oil in the turbine governor hydraulic control systems, oil storage tanks, or other equipment would need to be removed.

Iron Gate Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse facilities at Iron Gate Dam ($300,000) which is considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and removal of the structure itself. If the intent was to demolish the entire power plant, the following major mechanical equipment would need to be removed from the plant and trucked off site: one 25,000 HP vertical Francis hydraulic turbine unit, one turbine governor hydraulic control system with oil storage reservoir and pressure tank, one turbine runner spiral casing and head cover/operating ring, two turbine gate hydraulic servomotors, one vertical turbine shaft, one 12-foot-diameter turbine penstock pipe from intake structure to powerhouse, one 96-inch-diameter bypass pipe off penstock around unit to tailrace, one 30-inch-diameter water supply pipe from intake structure to fish facilities, one penstock vertical air vent pipe, one turbine draft tube, three draft tube bulkhead gates, four vertical turbine pumps on powerhouse tailrace deck for fish ladder water supply, a plant vertical sump pump, bearing oil storage tanks, 150-ton generator gantry crane and structural members, and other miscellaneous mechanical equipment, piping, and valves. The mechanical equipment removal costs would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Although there were no known hazardous materials identified at the time of the Team's site visit; there may be asbestos, bearing and governor hydraulic oils, PCB's, or coatings containing heavy metals in the plant and on the exterior surfaces of the outside steel penstock and bypass pipes, penstock vertical air vent pipe, bulkhead gate, and generator gantry crane which would need specialized abatement requirements.

The Staff dam removal options in the Final EIS report assumed that part of the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, mechanical equipment could be left in place with all power connections to the outside removed. Any oil in the turbine governor hydraulic control system, oil storage tanks, or other equipment would still need to be removed. The generator overhead gantry crane at this plant is outdoor equipment which may be viewed as unsightly or a potential hazard to people. If the crane were removed then all equipment would need to be hauled off the project site and the units would have to be disassembled in several sections prior to being trucked off site.

Electrical Engineering Review of Dam Removal Plans

J.C. Boyle Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse and generation facilities at J.C. Boyle Dam ($150,000), plus a single item to remove the substation ($150,000), which are considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and substation and removal of the structure itself. If the intent was to demolish the entire power plant, the following major electrical equipment would need to be removed from the plant and trucked off site: plant transformers, distribution equipment, unit breaker, two generators with a combined capacity of 98 MW, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. The substation would need to be removed and all transformers, breakers, switches, and take-off structures would need to be hauled away. The electrical equipment removal costs would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Specialized abatement requirements for any hazardous materials would add to the removal costs.

The Staff dam removal options in the Final EIS report indicated that the Powerhouse structure did not need to removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, electrical equipment could be left in place with all power connections to the outside removed. Any oil in transformers or other equipment would still need to be removed. The generators at this plant are outdoor equipment which may be viewed as unsightly or a potential hazard to people. If the generators were to be removed, then all equipment would need to be hauled off the project site and the units would have to be disassembled in several sections prior to being trucked off site.

Costs for removal of the transmission lines were not included in the GEC estimate and would be significant. Approximately ¼ mile of 69 kV transmission line and associated poles would need to be removed from the J.C. Boyle substation to where it connects to the PacifiCorp centralized substation located between Copco No. 1 and near Copco No. 2 powerhouses. The existing transmission lines cross over steep terrain in some areas which would drive up removal costs.

Copco No. 1 Dam and Powerhouse

The GEC report identified a single lump sum pay item to demolish the powerhouse structure at Copco No. 1 Dam ($275,000), plus a single item to remove the substation ($100,000), which are considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and substation and removal of the structure itself. If the intent was to demolish the entire powerplant, the following major electrical equipment would need to be removed from the plant and trucked off site: plant transformers, distribution equipment, unit breaker, two 10 MW generators, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. The substation and take-off structures would need to be hauled away. The electrical equipment removal costs would be significant due to the remoteness of the site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Specialized abatement requirements for any hazardous materials would add to the removal costs.

The Staff dam removal options in the Final EIS report assumed that the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario electrical equipment could be left in place with all power connections to the outside removed. Any oil in transformers or other equipment would still need to be removed.

Costs for removal of the transmission lines were not included in the GEC estimate and would be significant. Approximately 3/4 mile of 69 kV transmission line and associated poles would need to be removed from Copco No. 1 take off structure to where it connects to the PacifiCorp centralized substation located between Copco No. 1 and near Copco No. 2 powerhouses. The existing transmission lines cross over steep terrain in some areas which would drive up removal costs.

Copco No. 2 Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse facilities at Copco No. 2 Dam ($150,000), plus a single item to remove the substation ($150,000), which are considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and substation and removal of the structure itself. If the intent was to demolish the entire power plant, the following major electrical equipment would need to be removed from the plant and trucked off site: plant transformers, distribution equipment, unit breaker, two 13.5 MW generators, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. The substation would need to be removed and all transformers, breakers, switches, and take-off structures would need to be hauled away. The electrical equipment removal costs would be significant due to remoteness of site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Specialized abatement requirements for any hazardous materials would add to the removal costs.

The Staff dam removal options in the Final EIS report assumed that the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, electrical equipment could be left in place with all power connections to the outside removed. Any oil in transformers or other equipment would still need to be removed.

Costs for removal of the transmission lines were not included in the GEC estimate and would be significant. Approximately 1¼ mile of 69 kV transmission line and associated poles would need to be removed from Copco No. 2 substation to where its connects to the PacifiCorp centralized substation located between Copco No. 1 and near Copco No. 2 powerhouses. The transmission lines cross over steep terrain in some areas which would drive up removal costs.

Iron Gate Dam and Powerhouse

The GEC report identified a single lump sum pay item to remove the powerhouse facilities at Iron Gate Dam ($300,000), plus a single item to remove the substation ($150,000), which are considered by the Team to be extremely low considering the costs of removing all electrical and mechanical equipment from the plant and substation and removal of the structure itself. If the intent was to demolish the entire powerplant , the following major electrical equipment would need to be removed from the plant and trucked off site to a off-Project removal site: plant transformers, distribution equipment, unit breaker, one 18 MW generator, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. The substation would need to be removed and all transformers, breakers, switches, and take-off structures would need to be hauled away. The electrical equipment removal costs would be significant due to remoteness of site and the requirement to truck all materials off project to a suitable dump site or salvage collection point. Specialized abatement requirements for any hazardous materials would add to the removal costs.

The Staff dam removal options in the Final EIS report assumed that part of the Powerhouse structure did not need to be removed as part of the decommissioning project and that it could be retained with the plant boarded up or sealed. In this scenario, electrical equipment could be left in place with all power connections to the outside removed. Any oil in transformers or other equipment would still need to be removed.

Costs for removal of the transmission lines were not included in the GEC estimate and would be significant   Approximately 6-1/2 miles of 69 kV transmission line and associated poles would need to be removed from Iron Gate switchyard to where it connects to the PacifiCorp centralized substation located between Copco No. 1 and near Copco No. 2 powerhouses.   The transmission lines cross over steep terrain in some areas which would drive up removal costs.

Comments on Sediment Management Plans

Review of Gathard Engineering (2006)

General Comments

The GEC report presents a general study on the feasibility of the removal of four dams on the Klamath River: Iron Gate, Copco No. 2, Copco No. 1, and J.C. Boyle. The GEC report contains the following items:

1. General hydrologic and geologic descriptions of river;
2. Analysis of sediment volumes stored in reservoirs;
3. Reporting of sediment composition;
4. Description of various reservoir drawdown approaches;
5. A description of a proposed dam removal strategy;
6. General description of project impacts; and
7. Cost estimates of proposed dam removal strategy.

The analysis of sediment volumes indicates that there are still large uncertainties in the reservoir volumes. The background information for the different approaches for computing the sediment volume by reservoirs was provided in Appendix C, Section C1.1. entitled “Volume Analysis”. Throughout the GEC report it is indicated that limited to no original topographic data were available for the four reservoirs being investigated.

Reviewing the summary of the analysis along with the appendices, the approach for determining the sediment volume appears reasonable considering the limited data available and the information presented. The uncertainties in the pre-dam surface and the sediment volume stored in the reservoir should be reduced. For natural erosion alternatives, the erosion will likely only be limited by the pre-dam channel or bedrock locations. The impacts to the downstream channel will be proportional to the volume of sediment release at the dam and obtaining an accurate volume is important in assessing impacts and costs of sediment management strategies. Additional drilling, surveying, and/or geophysical techniques may be required to reduce these uncertainties.

To obtain a more accurate estimate of reservoir sediment volume, one option is to conduct a survey using a dual frequency or subbottom profiling system. From the core sediment sampling results it is stated that 78 percent of the sediment deposit for all four dams is smaller than silt size material. With nearly eighty percent of the material in the silt range, a low frequency system might be able to map the thickness of the deposited material. A means for quality assurance when using such a system is to collect data at the core sampling sites, then compare results of the measured sediment thickness. Once calibrated, cross sections could be collected throughout the reservoir. The system could collect the top of the sediment along with the original subbottom of the reservoir during the same cross section profile. The difference between the two depths would be used to compute the sediment deposition volume. These collection systems are not a fool-proof means for conducting such studies and would have to be tested for the reservoir conditions that would be encountered for these reservoirs, but having such fine sediments should increase the possibility of utilizing a dual frequency sounder with good results.

The methods used by GEC to analyze the physical and chemical properties of the sediments were adequate and the number of samples collected seems reasonable for the level of analysis in the report. However, considering the size of the impoundments and cost of dam removal, more samples should be collected before design of the proposed removal strategy. FERC (2007) also recommends additional sediment sampling (p.3-58). The future sampling will also have to include samples at greater depths. The previous sampling only had one sample collected at a sediment depth of more than 10 feet and that was in J.C. Boyle. All but two samples collected in Copco No. 1 were collected at sediment depths of less than 6 feet. More samples should be collected at greater depths to better understand the physical and chemical properties of the reservoir sediments. These samples could show that the deeper sediments are more resistant to erosion and verify they do not contain significant levels of hazardous material.

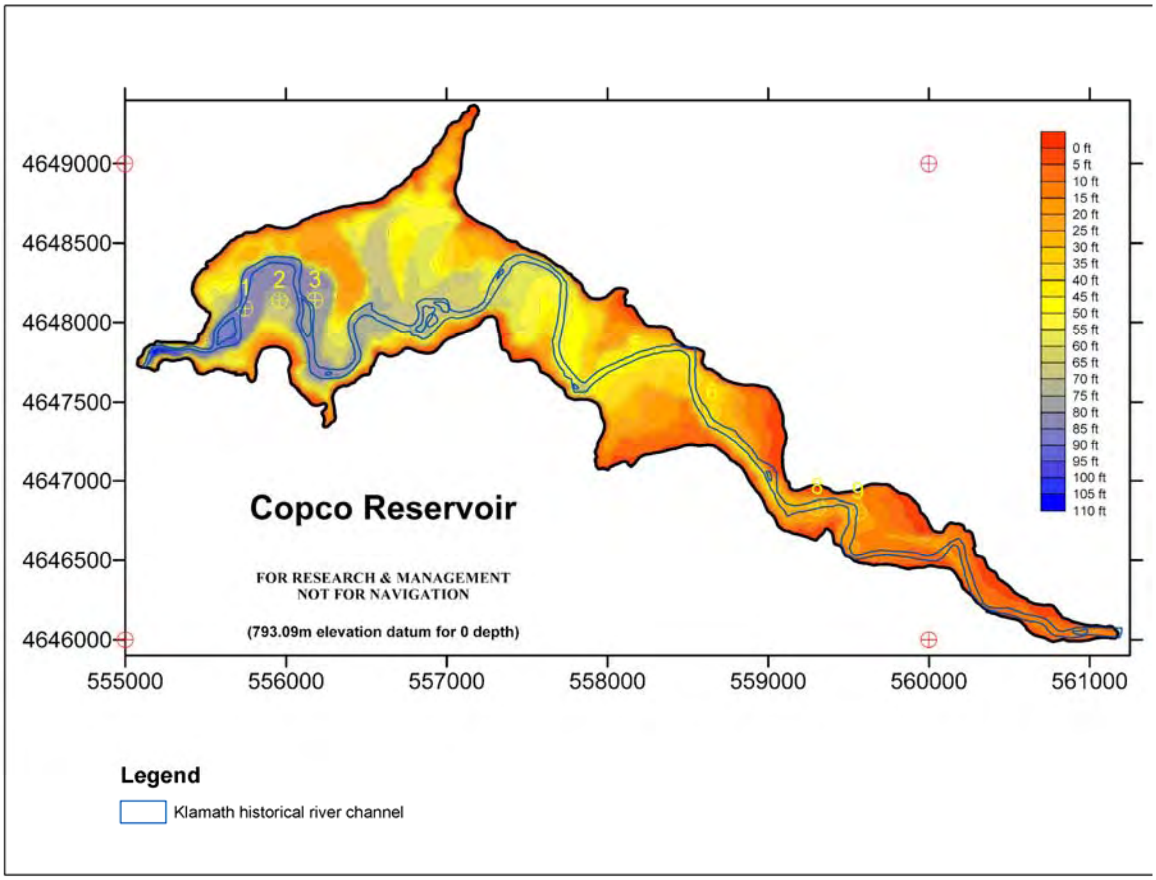
While the sampled sediments to date do not contain significant levels of hazardous material, the high sediment concentrations released during and after reservoir drawdown can cause other water quality concerns. Fine sediments can temporarily intrude into bed material and reduce fish egg survival. Organic material in the sediments can reduce dissolved oxygen concentrations. High sediment concentrations can increase water treatment costs or prevent downstream water diversions altogether if the intended use or distribution systems are sensitive to high sediment concentrations. The oxidation of reduced metals can also create potential water quality concerns. These water quality concerns must be addressed and quantified before the final costs of dam removal can be determined. None of these impacts is permanent or necessarily large and there will likely be long term improvements to water quality as the result of dam removal, but the temporary increases in suspended sediment and nutrient loads need to be quantified. None of the above water quality concerns was fully addressed in Gathard (2006) and the current sediment modeling plans seem to only consider the physical sediment aspects of Total Suspended Solids (TSS) and deposition amounts. No other current studies addressing this issue are known.

The Team does not believe that the duration of sediment impacts is well understood at this time. The GEC report seems to assume that water quality impacts will be isolated to the reservoir drawdown period. The only additional erosion of reservoir material is assumed to occur during subsequent high flow events with already high sediment concentrations. However, the sediment concentrations may be higher than background concentrations for a longer period of time than assumed by the GEC report. The reservoir material was assumed to obtain stable 10:1 slopes in a relatively short period, but it may require several months to drain the reservoir sediment, and continual sloughing of material into the channel may occur after the initial drawdown for an extended period of time. This was observed at Lake Powell during the spring of 2004, when even after the reservoir elevation had stabilized following a drawdown, bank erosion continued to occur because of the low strength of the reservoir sediments. Shannon and Wilson (2006) state: “For planning purposes, to estimate sediment volume eroded from the reservoir following initial rapid drawdown and the first winter storms, we recommend assuming that soil will erode above surfaces projected at 10 horizontal to 1 vertical (10H:1V) upward from the projected stream edge. However, it is likely that all of this material will not mobilize during the first winter it is exposed. Additional studies to attempt to quantify erosion impacts beyond the first season may be required." The Team concurs with these statements and believes that suspended sediment concentrations will be significantly elevated downstream of the dams for up to one year. Further analysis of the detailed erosion and drainage characteristics of the sediment needs to be performed if less conservative assumptions are made. Currently, GEC is taking a conservative approach to estimate sediment volumes, but the Team believes GEC is not taking a conservative approach in estimating the duration of elevated sediment concentrations downstream. It is uncertain if their final estimate of downstream sediment impacts is accurate or conservative. The Team believes that reducing the uncertainty in the volume of sediment and pre-dam surface would cost a relatively small amount and improve the ability to estimate sediment impacts and plan dam removal schedules and mitigations.

It was also assumed by GEC that the river channel would immediately find the pre-dam channel. Based upon the reservoir topography map, the current deepest point generally follows the historical pre-dam channel (see figure of Copco No. 1 Reservoir below for an example). However, there may be some locations where this does not occur. The initial channel may form in a different location than the pre-dam channel. As the channel works its way to the pre-dam channel, it will erode additional reservoir sediment. If the above scenario occurs, the duration of downstream impacts could be extended past the initial drawdown period. In another scenario, the river finds the historic channel immediately but, because the sediments are fine and cohesive, the sediments drain slowly and as they drain the sediments slough off into the channel. The impacts from either of these scenarios may still be acceptable, but the Team believes that there has not been sufficient analysis to discount these possibilities. The Team recommends that a more accurate pre-dam surface be developed. Also, the draining characteristics of the sediment should be quantified because it may take much longer than GEC assumed for the reservoir sediment to drain and stabilize.

In addition, the volume of released sediments could be more than the estimated 4 million yd^3 in the GEC report. GEC assumed that about ¼ of the total available sediment would be eroded from the reservoir. While this is a reasonable estimate, it assumes that the historic channel is immediately occupied by the river channel. Furthermore, the remaining sediment on the terraces may not stabilize at 10:1 slopes.

More scenarios need to be considered to fully assess potential downstream impacts. There should be contingency plans for handling elevated sediment concentrations for extended periods or at least an acknowledgement of the possibility of continued elevated sediment concentrations. The Team suggests making an estimate of the uncertainties of the sediment impacts and developing a range of possible sediment impacts. The estimated dam removal costs and mitigation measures should incorporate these uncertainties. Currently, the report does not fully acknowledge the potential for a longer duration of elevated sediment concentrations.



The GEC report identified the water users downstream of the dam and proposed potential mitigation measures. The costs for those mitigation measures are identified. However, additional analysis needs to be performed to determine whether the mitigation measures are sufficient. The mitigation costs for water quality impacts ($1.6 million) are significantly lower than for similarly sized projects. As mentioned previously, these costs for mitigation are probably somewhere between appraisal-level and feasibility-level estimates.

The release of reservoir sediment will not cause significant channel deposition because the downstream river is relatively high energy and the reservoir sediment is relatively fine. Stillwater Sciences (2004) also concluded the downstream deposition is not a significant concern.

Specific Comments

Section 1.3.5, First Paragraph: States existing low level outlets may be used for draw down for Iron Gate and J.C. Boyle Dams followed by last sentence stating a new outlet gate is needed on Iron Gate Dam. The diversion tunnel at Iron Gate Dam has been recently modified by PacifiCorp. The costs associated with opening low-level outlets at the dams need to be quantified. At Copco 1, sediment currently submerges the outlet being proposed to drain the reservoir. The sediment covering this outlet may have to be excavated to ensure that the outlet can be opened to drain the reservoir.

Page 29: Discuss the possibility of oxidation of metals adsorbed to the sediment and possible impacts.

Page 31: Method to calculate the sediment volume may miss the volume of sediment stored in the above water delta. The size of the delta should also be assessed.

Page 35: The sediment concentrations could vary more than a factor of 2 from the results presented in Figure 13.

Page 37: Vegetation is unlikely to stabilize banks that are much higher than the root zone.

Page 37: These estimates could be off by more than an order of magnitude. Sediment concentrations for the first few flows after dam removal could be higher than 100,000 ppm.

Page 43: There seems to be an assumption that high TSS levels will only occur during the drawdown process. There will also be a time after drawdown that erosion continues to occur.

Page 45, Figure 16: Again, sediment concentrations could be much larger than 10,000 to 15,000 ppm.

Page 50: It may be too early to have a preferred alternative. Need to first quantify downstream impacts.

Page 50: Agree with the statement: "Total suspended sediment (TSS) levels downstream of Iron Gate Dam may temporarily exceed 50,000 parts per million (ppm) and average above 20,000 ppm for days during the reservoir drawdown period." However, the graphs in the report show concentrations much lower.

Page 93: It was mentioned there were land owners near the reservoirs. Will they have to be compensated?

Page 95, Section 11: More sediment may remain in the reservoir with high drawdown rates. The statement: "Consequently, less sediment remains in the reservoirs after drawdown." is not supported.

Review of Stillwater Sciences (2006)

Dilution factors are reasonable and the analysis is straightforward. As mentioned in the report, this analysis needs to be followed by an analysis of the erosion of fine sediment in the reservoirs. The analysis assumes that tributaries supply only flow and no additional sediment. The sediment concentrations in tributaries may be low enough to ignore, but this should be verified. Furthermore, this analysis does not fully address nutrient and water quality concerns downstream.

Review of Gathard Engineering (2007)

This report analyzed the difference between initiating reservoir drawdown in November or December as opposed to October. One of the major goals of the analysis was to compute the number of days after May 1 that would have high suspended sediment concentrations. With the current outlet capacities, most years result in high suspended sediment concentrations after May 1. The release capacity of Copco No. 1 Dam was considered to limit the ability to control the timing of high suspended sediment concentrations. If the outlet gate discharge capacity of Copco No. 1 Dam were increased, there would be greater ability to limit the number of days after May 1 where there were high suspended sediment concentrations. The potential discharge capacity of the existing outlet, and the cost of increasing the discharge capacity of the outlet, have not been determined.

The analyses presented in this report assume that the reservoir sediment processes are reasonably accurate and this assumption has not been proven, as stated in the above review of Gathard (2006). At this stage of analysis, it is advisable to plan on elevated sediment concentrations beyond the initial drawdown period regardless of outlet discharge capacity. The models used to predict reservoir erosion are not sufficiently tested or refined to guarantee that impacts will be limited to a certain period. The model is accurate in predicting that the concentrations will be highest during the drawdown period, but the rate at which they decrease after the initial drawdown remains uncertain.

Review of Section 3 of FERC (2007)

Page 3-41 to 3-51: There is disagreement between the FERC (2007) analysis and the PacifiCorp (2005) analysis regarding bedload sediment. The results are summarized in FERC (2007), Table 3-8, p. 3-45. PacifiCorp states that the deficit of bedload in the Klamath River caused by the Project only extends to the confluence of Klamath River and Cottonwood Creek. This is an over simplification because it ignores the dynamics of river processes. The sediment deficit caused by a dam continues to progress downstream as the dam traps more sediment. As soon as the dam is constructed, the river begins to mine sediment from the river bed and banks starting at the dam. As the upstream reaches become armored, this mining progresses downstream. This process continues throughout the life of the dam. Therefore, the deficit in sediment transport progresses downstream as the dams age. This process can occur relatively slowly and as tributaries enter into the downstream reach, the relative effects of the sediment deficit become less. It is estimated that currently the sediment deficit is only important near the dam. FERC estimates that the sediment deficit extends to Scott River, and this would seem to be a more reasonable estimate. However, it should be remembered that the sediment deficit is a relative term and that the effect of the dams becomes *gradually* less as one goes downstream. It is certain, however, that removal of the dams will have no discernable effect on the coarse sediment load provided to the Pacific Coast.

The most direct method to compute the sediment deficit below a dam is to compute the volume of sediment stored behind the dam. This is the natural sediment load to which the organisms of the river had adapted and upon which they depend. The amount of gravel material that is required to mitigate the impact of the dam should be related to the volume of material trapped by the dam.

Page 3-156: There is disagreement as to whether the PacifiCorp Reservoirs act as sinks or sources of nutrients. FERC (2007) quotes a study by Kann and Asarian (2005) that suggests that Copco No. 1 and Iron Gate Reservoirs act as sinks for the nutrients phosphorous and nitrogen during April, May, parts of July and August, and October, but both reservoirs can act as a nutrient source to the Klamath River below Iron Gate Dam during most of June and September. There is also disagreement regarding the potential reservoir water temperature effects on fish.

Page 3-168: FERC seems to be recommending that Copco No. 1 Dam be removed before Iron Gate and Iron Gate be used to trap the sediment eroded from Copco No. 1 Dam. The trapping efficiency of Iron Gate Dam is not well enough understood to quantify. The GEC report recommends that all four reservoirs be drawn down concurrently. The difference in impacts between the two strategies may be significant. More analysis must be done to quantify these differences.

Page 3-170: FERC states: "Habitat downstream of Iron Gate Dam would be able to recover from the initial increased TSS levels during removal of upstream dams and because periods of elevated TSS would only be expected to occur for about 4 months, the timing of the sequential dam removal could be adjusted to correspond with periods when key lifestages of salmonids would be least affected." However, the actual duration of elevated TSS levels is not well understood at this level of design. It is likely that 4 months is a reasonable estimate, but the Team does not believe that sufficient analysis has been done to prove that this number is correct. A more complete analysis of the potential uncertainties should be performed.

Page 3-173: FERC is stating that elevated suspended sediment concentrations will last between 40 and 120 days. See comments above.

Comments on Constructability Issues

J.C. Boyle Dam

The description in the GEC report of the construction equipment required to remove the embankment is generally accurate. The size (12 cubic yards) and number (16) of the trucks does not seem to be practical though. A fewer number of larger trucks (40 ton) working two shifts would seem to be more feasible. Expected production rates would be on the order of 400 cubic yards per hour using 3 or 4, 40 ton trucks and one excavator.

The use of the original borrow pits located on the right abutment for waste areas seems reasonable. Some initial clearing and restoration upon completion would be required. A high voltage power line that crosses both proposed waste areas would require precautions and restrict the amount of material that could be wasted beneath the line. However, it appears there would still be ample area for wasting the embankment. Minor improvements to the existing haul roads will be required.

It was not clear whether the waste concrete would be allowed to be disposed onsite. If not, additional costs would be incurred to haul the material to a landfill or recycling facility.

It appears the reservoir sediment is at elevation 3765 at the dam. The bypass culverts have an invert elevation of 3752 feet. It should be anticipated that the removal of the concrete stoplogs may be problematic due to being silted in and under water. If the culverts are actually used, then considerable sluicing of the sediments immediately upstream of the dam will occur. It is possible the sediments contain woody debris which could create a plug preventing the draining of the reservoir.

Copco No. 1 Dam

The dam and power plant is situated in a steep narrow canyon. The existing access roads will require significant upgrading to handle the hauling of the excavated concrete and provide access for a large crawler-mounted crane.

The brief discussion in the GEC report of the construction of the low level gated tunnel did not address how the tunnel would breach the upstream face of the dam. It appears there would still be approximately 105 feet of water against the dam at the time the tunnel breaches into the reservoir. There was no discussion of developing access for the construction of the low level gated tunnel or associated costs.

The demolition of the concrete gravity arch dam may prove to be more complicated than depicted in the report. Regardless of the method chosen to release the sediments in the reservoir, the gravity arch dam most probably will be demolished in horizontal lifts. Progress will be slowed initially by the need to remove the spillway bridge deck, gates, and piers. The narrow top width will also slow the removal.

During the initial construction, upstream and downstream concrete cutoff walls were constructed to carry out the excavation of the river channel. These walls were then incorporated into the final structure. Most likely these walls were reinforced. Demolition of these walls will require additional effort most likely not accounted for in the GEC estimate.

The historical records also indicated the mass concrete was reinforced with 30 pound steel rails. The effort required to demolish the concrete will be greater and the duration potentially significantly longer. The steel rails will also hamper drilling blast holes.

There was no line item in the GEC cost estimate for removal and control of water. Once the excavation reaches the level of the tunnel, moving the stream from side to side will be required.

Copco No. 2 Dam

The discussion in the GEC report of drilling and packing the dam with explosives prior to drying up the river does not seem appropriate. Loaded holes should be detonated on the same shift they are loaded and not left for an extended period of time, for safety reasons. Otherwise the site would need to be guarded around the clock until the explosives were detonated.

The concept of using a cofferdam to divert flows into the intake tunnel would seem the most appropriate. The majority of the spillway, gravity structure, cutoff wall, and earthen embankment could then be demolished using conventional methods. The demolition would most likely require longer durations than shown in the GEC report.

There was no line item in the GEC cost estimate for removal and control of water.

Iron Gate Dam

The final disposal sites for the dam embankment material have not been determined. Several potential sites have been identified in the GEC report, with the site nearest the dam assumed for the cost estimate. This assumption would tend to make the cost estimate less conservative.

The GEC report assumed the existing tunnel would be used to divert flows around the dam during demolition down to approximate elevation 2200. As the GEC report suggests, additional investigation is required to determine the feasibility and cost of modifying the tunnel or providing an alternate diversion. Recent modifications to the tunnel by PacifiCorp have not been addressed.

The description of the construction equipment required to remove the embankment is generally accurate. The size (12 cubic yards) and number (54) of the trucks does not seem to be practical though. A fewer number of larger trucks (40 ton) working two shifts would seem to be more feasible.

Excavation of the embankment begins on the very narrow crest section and production rates will be very low due to the confined work area. As the excavation descends, the footprint becomes wider and additional equipment can be added to the equipment spread. The removal of the riprap most likely will occur as the embankment is excavated down.

The GEC report acknowledges the fact that haul roads will need to be improved to handle two-way traffic of large construction equipment. However, the costs to widen the haul roads do not appear to be adequate. In addition, the disposal site location could have a significant impact on the costs to upgrade or construct the haul roads. Also, as the excavation descends, ramps out of the canyon have to be constructed and moved.

To achieve the desired daily production rates, shift work will be required. The additional costs for overtime and equipment maintenance should be accounted for in the GEC cost estimate.

There was not enough information on the cofferdam sheet pile diversion channel to fully understand the design. If the foundation of the cofferdam is on rock or cobbles, driving sheet pile to create a cantilever sheet pile wall doesn't seem feasible. In addition, the height of the sheet pile could not be determined, but appeared to be higher than what could be constructed as unsupported.

The materials used in the construction cofferdam were not described. The presence of cobbles or boulders could cause significant problems driving the sheet pile. There was no mention of a downstream cofferdam in the GEC report. Consideration should be given to the fact that material from the lower embankment and cofferdam will be saturated.

There were no line items for removal and control of water or for dust control in the GEC cost estimate. There was also no discussion of air quality emissions mitigation or costs.

Comments on Construction Costs

The following comments on construction costs are numbered for reference purposes.

J.C. Boyle Dam and Powerhouse

1. The GEC report included a line item titled "Demolish Outer Canal Wall" consisting of 10,000 yd^3 totaling $4,000,000. It is unclear if this demolished material was to be hauled to recycler, landfill, or buried on site in a "stable storage location" (all listed possibilities in Section 6.7 Cost Estimates). There will be significant cost differences amongst these various assumptions. One assumption should be made, clearly delineated in the text or in the cost estimate, and priced accordingly.
2. It is not clear how the quantity for the item in 1. above was computed. If GEC assumes recycling or disposal at a local landfill, the concrete volume after demolition should be bulked up for recycling/disposal purposes and priced accordingly – and certainly for any haul cost computations. Also listed is a line item for haul for this rubble for a distance of 10 miles. A recycler/landfill should be identified for feasibility design and haul distances be computed to closely develop haul costs for this rubble.
3. The costs for demolition and removal of the downstream pipeline and penstock pipe to the plant, as well as for tunnel portal removal and sealing, should be included in the GEC cost estimate as is identified in the Final EIS decommissioning assumptions.
4. The cost included in the GEC estimate for "Removing Powerhouse and Generation Facilities" appears significantly low. This lump sum should be revisited and revised based on the significant amount of work in decommissioning and demolition of the plant. This will include abatement of asbestos and lead based paint within the plant.
5. Based on the Team's site visit, it appears that local Bureau of Land Management (BLM) Campsites and /or boat ramps exist on the reservoir. After demolition, there may be a need to address establishing new facilities (mitigation) in place of

existing facilities. Consideration should be given to the addition of a non-contract cost line item for project mitigation requirements – and dollars added for these mitigation requirements.

6. The unit prices shown in the GEC cost estimate for earthen dam excavation, haul, and waste appear to be reasonable (based on assumptions made for the cost estimate). However, the assumption in the GEC report regarding the use of 12 yd^3 trucks for haul to waste areas does not seem reasonable. Most likely, this project will benefit from the use of larger haul units for this effort.
7. GEC suggests placement of earthen dam removal spoil material adjacent to the dam (identified by GEC representative on the Team's site visit off of the right abutment approximately 500 feet). NOTE: Some question exists if this waste area identified on the site visit is available for this use. This should be confirmed. If this disposal area is not available for waste of the dam embankment materials, requiring haul to an area farther from the site, this will result in significant additional costs. Disposal areas should be investigated and confirmed.
8. The following items identified as additional decommissioning assumptions in the Final EIS should be considered and added to the GEC cost estimate (to insure adequate funding levels):
    a. Removal of the Canal Spillway
    b. Removal of the Tunnel Entrance Structure
    c. Sealing of Tunnel Portals
    d. Dismantling/Removing Powerhouse Crane
    e. Regrading and Vegetating Dam Abutments
    f. Backfilling and Regrading Tailrace Channel Area
    g. Backfilling and Regrading Canal Spillway Channel Area
    h. Removal of 69kV Transmission Line
    i. Restoration of Transmission Line ROW
    j. Removal of Warehouse and/or Support Buildings
9. GEC included a line item for "Removing Spillway and Gates" of $50,000. This cost appears significantly low for this work as interpreted from the Team's site visit.
10. It is unclear what work items are included in the line item titled "Remove and Salvage Steel" in the GEC report. Additional information should be provided to delineate assumptions included in this line item and cost.
11. Section 6.7 Cost Estimates in the GEC report lists general assumptions applied to all cost estimates. It is noted that costs for recycling of concrete rubble (such as crushing concrete and/or hauling of recycled reinforcing steel) are not included in the GEC cost estimates. It is recommended that costs for these assumptions be included in the cost estimates as appropriate.
12. A line item in the GEC cost estimate for "Upgrade Roads" for a total of $5,000 was included. When considering all of the truck trips that would be required off of the site, this cost appears significantly low. Development of roads and more importantly repair of roads after completion of the work likely would result in a significantly larger cost.
13. GEC should provide additional information describing the items included in the line item for "Construction Management Facilities". If this represents typical

Project Management related items (including labor), it is the Team's experience that this could total to approximately 10 to 15 percent of the cost of the job – which would be significantly higher than is provided for in the GEC cost estimate.

Copco No. 1 Dam and Powerhouse

1. The line item in the GEC cost estimate for "Upgrade Roads" appears significantly low. This road is a narrow, winding road with tight curves that likely would require widening to accommodate haul trucks for removal of concrete debris off of the project site.
2. GEC suggests the demolition of the concrete dam would be conducted using drilling and blasting techniques. Depending on the requirements associated with downstream sediment loading, this may not be an acceptable assumption. If a surgical demolition process is required (ie. Diamond-wire sawcutting for block removal), the unit cost for concrete demolition of the dam will increase. GEC indicates that reinforcing steel would be removed and recycled. Section 6.7 Cost Estimates in the GEC report lists general assumptions applied to all cost estimates. It is noted that costs for recycling of concrete rubble (such as crushing concrete and/or hauling of recycled reinforcing steel) are not included in the GEC cost estimates. It is recommended that costs for these assumptions be included in the cost estimates as appropriate.
3. The cost estimate associated with a Tower Crane and Operator for $5,000 per month appears low. No pricing information for this item was provided in the GEC report.
4. GEC should provide additional information describing the items included in the line item for "Construction Management Facilities". If this represents typical Project Management related items (including labor), it is the Team's experience that this could total to approximately 10 to 15 percent of the cost of the job – which would be significantly higher than is provided for in the GEC cost estimate.
5. No information was provided in the GEC report describing the concrete rubble disposal assumptions. Based on the unit price for haul cost (Haul Materials), it is assumed that the disposal location adopted by GEC is located within 2-3 miles of the dam site. The assumption that this concrete rubble can be disposed of on-site or at a nearby disposal location is questionable. Additional research should be completed to identify a recycler, municipal landfill, or confirmed disposal location to more closely estimate the costs associated with haul and any required disposal fees or costs. If GEC decides to assume recycling or disposal at a local landfill, it is recommended that the concrete volume after demolition be bulked up for recycling/disposal purposes and priced accordingly – and certainly for any haul cost computations.
6. The cost included in the GEC cost estimate for "Demolishing Powerhouse Structure" appears significantly low. This lump sum should be revisited and revised based on the significant amount of work in decommissioning the plant, equipment, and demolition of the building. This will include abatement of asbestos and lead based paint within the plant.
7. GEC included a line item for "Removing Spillway and Gates" of $50,000. This cost appears significantly low for this work as interpreted from the Team's visit.

8. The Lump Sum included in the GEC cost estimate for "Remove and Recycle Penstock" is significantly low. This number needs to be revisited.
9. Getting equipment to the base of the dam to collect and load blasted concrete rubble into buckets for the tower crane will be extremely difficult. Concrete demolition, loading, haul, and disposal is a major cost driver for this facility. As such, additional thought and layout should be considered by GEC in the pricing for this facility. All things considered, the cost for removal of this facility could easily double from what is presented in the GEC cost estimate.
10. The following items identified as additional decommissioning assumptions in the Final EIS should be considered and added to the cost estimate (to insure adequate funding levels):
    a. Removal of 69kV Transmission Line
    b. Restoring Transmission Line ROW

Copco No. 2 Dam and Powerhouse

1. The line item in the GEC cost estimate for "Upgrade Roads" appears significantly low. This road is a narrow, winding road with tight curves that likely would require widening to accommodate haul trucks for removal of concrete debris off of the project site.
2. GEC suggests the demolition of the concrete dam would be conducted using drilling and blasting techniques. This may not be an acceptable assumption. If a surgical demolition process is required (ie. Diamond-wire sawcutting for block removal), the unit cost for concrete demolition of the dam will increase. GEC indicates that reinforcing steel would be removed and recycled. Section 6.7 Cost Estimates in the GEC report lists general assumptions applied to all cost estimates. It is noted that costs for recycling of concrete rubble (such as crushing concrete and/or hauling of recycled reinforcing steel) are not included in the GEC cost estimates. It is recommended that costs for these assumptions be included in the cost estimates as appropriate.
3. No information was provided in the GEC report describing the concrete rubble disposal assumptions. The assumption that this concrete rubble can be disposed of on-site or nearby is questionable. Additional research should be completed to identify a recycler, municipal landfill, or confirmed disposal location to more closely estimate the costs associated with haul and any required disposal fees or costs. If GEC decides to assume recycling or disposal at a local landfill, it is recommended that the concrete volume after demolition be bulked up for recycling/disposal purposes and priced accordingly – and certainly for any haul cost computations.
4. GEC did not include a line item for "Construction Management Facilities" as was done for other features. This should be included in this cost estimate. If this item represents typical Project Management related items (including labor), it is the Team's experience that this could total to approximately 10 to 15 percent of the cost of the job.
5. GEC has proposed the use of jersey barriers for construction of a cofferdam to direct stream flows to the power tunnel or conduit while demolition of the dam begins. This may not be practical. A more robust cofferdam design and

requirement could exceed the cost estimated for this line item (ie. Temp Diversion Cofferdam = $50,000).

6. The cost estimated by GEC for "Remove Spillway and Gates" appears significantly low.
7. Removal of the intake structure and associated steelwork on the left abutment will be substantial. The cost estimated by GEC for "Remove Intake Structure" at $50,000 appears low.
8. The cost included in the GEC estimate for "Remove Powerhouse Facilities" appears significantly low. This lump sum should be revisited and revised based on the significant amount of work in decommissioning the plant and demolition of the plant. This will include abatement of asbestos and lead based paint within the plant.
9. The line item for "Remove Penstock" priced at $35 per linear foot seems low (based on a visual reference from the Team's site visit). The penstock heads up the hill from the powerhouse. This will prove difficult to get to that pipe.
10. The following items identified as additional decommissioning assumptions in the Final EIS should be considered and added to the GEC cost estimate (to insure adequate funding levels):
    a. Removal of 69kV Transmission Line
    b. Restoring Transmission Line ROW

Iron Gate Dam and Powerhouse

1. The GEC cost estimate does not include a line item for removal of steel sheet pile that has been installed recently on the crest of the dam. This should be included.
2. GEC should provide additional information describing the items included in the line item for "Construction Management Facilities". If this represents typical Project Management related items (including labor), it is the Team's experience that this could total to approximately 10 to 15 percent of the cost of the job – which would be significantly higher than is provided for in the GEC cost estimate.
3. There is not enough information available in the GEC report to evaluate the reasonableness of the line items for "Tunnel Liner Modification" and "Flow Gate Control Modifications". These items are shown at $1,000,000 each.
4. GEC suggests placement of earthen dam removal spoil material up high on the left abutment approximately 1.25 miles from the dam. The haul road up to that proposed waste area is a very good, wide road. Little effort will be required for upgrade of the road. NOTE: Some question exists if this waste area identified on the site visit is available for this use. This should be confirmed. If this disposal area is not available for waste of the dam embankment materials, requiring haul to an area farther from the site, this will result in significant additional costs. Disposal areas should be investigated and confirmed.
5. The unit prices shown in the cost estimate for earthen dam excavation, haul, and waste are derived from the 2006 Mean's Heavy Cost Guide (based on an assumption of the use of 54 – 12 yd^3 trucks in cycle). The assumption in the GEC report regarding the use of 12 yd^3 trucks for haul to waste areas does not seem reasonable (both numbers and staggering distances). Most likely, this project will benefit from the use of larger haul units for this effort. As a portion of this

material will be placed in the spillway and the remainder will be hauled up the hill at 6% grades, this project may necessitate the use of articulated trucks that cost much more to operate.

6. In general, the duration of 4 months for all work on this facility from beginning to end as proposed in the GEC report seems overly optimistic. If the duration is extended dramatically, the project would realize costly extended overheads.
7. The cost included in the GEC estimate for "Remove Powerhouse Facilities" appears significantly low. This lump sum should be revisited and revised based on the significant amount of work in decommissioning the plant, equipment, and demolition of the building. This will include abatement of asbestos and lead based paint within the plant.
8. Insufficient information was available to evaluate the reasonableness of the item titled "Demolish Dam Tunnel Gate".
9. No information was available in the GEC report to understand the assumption for haul and disposal of the riprap. It is assumed that the riprap material is to be used on the project. Little money was included in this unit price of \$7.50 per yd^3 for hauling long distances or for surgical placement of the riprap.
10. The following items identified as additional decommissioning assumptions in the Final EIS should be considered and added to the cost estimate (to insure adequate funding levels):
    a. Backfilling and Regrading Powerhouse Tailrace Area
    b. Removal of 69kV Transmission Line
    c. Restoring Transmission Line ROW
11. The GEC cost estimate for Water Quality Protection includes line items for new fish hatchery facilities, off-stream rearing ponds, and hatchery water supplies downstream of Iron Gate Dam. Since this hatchery was originally required as mitigation for the construction of Iron Gate Dam, it may no longer be required following dam removal. The future disposition of the fish hatchery should be determined for feasibility design.
12. If the dam is removed, PacifiCorp personnel indicated that the 24-inch-diameter pipeline feeding the City of Yreka would likely need to be modified or replaced. The existing pipeline crosses the reservoir bottom on a gravel bed with some riprap protection. Exposure to higher river flows after reservoir drawdown is likely to cause problems for the existing installation. Burial of a new pipeline beneath the river bed is expected to be required. This item and cost should be added to the GEC estimate.

Conclusions

The following conclusions are provided as a result of the Reclamation Team review and evaluation of the GEC report and supporting documents:

1. The removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams is technically feasible, and the engineering assumptions made by GEC for removal of each dam seem reasonable for an appraisal-level study. However, more investigations are required to establish maximum reservoir drawdown rates and

associated construction schedules, and to determine the availability of existing diversion features at J.C. Boyle and Copco No. 1 Dams for reservoir drawdown.

2. Structure removal limits have not been well defined, and the removal quantities developed for the GEC report are considered to be at an appraisal level. All removal quantities should be revised using additional information available from PacifiCorp and other sources, and based on well-defined removal limits.
3. Estimated costs and unit prices for several items of work appear to be low, especially those associated with the removal of concrete structures and with the construction of temporary haul roads. Other features likely to be removed, such as transmission lines, were not included in the GEC cost estimate. Any construction schedule constraints due to sediment management, flood flows, or fishery requirements will further impact construction costs.
4. The removal of all four dams has been assumed to be performed concurrently in order to minimize the period of very high suspended sediment levels in the river. However, the Staff dam removal options in the Final EIS suggest that the removal of Iron Gate Dam may be delayed at least two years after the removal of upstream dams. This delay would increase the removal cost of Iron Gate Dam relative to the other dams. A cost escalation rate of 2.4 percent per year was assumed in the Final EIS. Iron Gate Dam is already the most costly feature to remove.
5. The GEC estimates include a contingency allowance of 25 percent to establish the total construction cost, and an allowance of 15 percent of the total construction cost for construction management, and 25 percent for engineering and permitting. It is assumed that other non-contract costs, such as for contract administration and environmental compliance, are included. The EIS assumed contingencies of 25 percent (50 percent for Copco No. 1 Dam), and allowances of 10 percent for engineering, 10 percent for construction management, and 3 percent for permitting and consultation. The GEC allowances seem more reasonable for this level of study. Significant uncertainty remains pertaining to potential environmental mitigation costs for the dam removals, including costs for water quality protection, fisheries restoration, and recreation.

The following sediment impacts are likely to result from the four dam removal option as proposed by GEC:

1. <u>Increase in suspended sediment concentrations downstream of dams</u>. There will be a temporary large increase and a long term small increase. The temporary large increase is due to the erosion of stored sediment. The long term small increase is due to the natural resupply of sediment to reaches downstream of the dams. The large increase may effectively last only during the reservoir drawdown period, however, this is uncertain and additional analysis is necessary. There will be significant uncertainty regarding the duration of impacts and it will be necessary to communicate this uncertainty to potentially affected parties. The long term small increase will likely have positive impacts to the riparian health of the downstream river reach, but could adversely affect downstream water users.
2. <u>Increase in gravel transport in the downstream reaches</u>. An increase in gravel transport is generally considered a benefit to the downstream habitat and would

eliminate the need for gravel augmentation programs currently under consideration by PacifiCorp. The resupply of gravels would benefit the aquatic habitat, in particular the spawning habitat downstream.

3. <u>The release of organic material stored in reservoir deposits</u>. The release of organic material stored in the reservoirs will affect the water quality downstream of the project. There is approximately 1.3 million tons of organic material stored behind the reservoirs. At least a quarter of this material will be released upon drawdown and perhaps more if the erosion scenario is not as anticipated in the GEC report. The organics may decrease dissolved oxygen levels and increase nutrient and ammonia levels. The spatial and temporal aspects of this impact have not been quantified.
4. <u>Change in riparian habitat in downstream river channel</u>. The altered flows under project conditions have likely limited the growth or recruitment of riparian species in reaches with large fluctuations in flow for power purposes and those reaches essentially dewatered by diversion. The effect of dams on riparian health is documented in p 3-54 to 3-55 of FERC (2007). The removal of the four dams may slowly reverse these conditions and gradually re-establish natural riparian communities.
5. <u>Temperature changes to downstream reach</u>. PacifiCorp simulated the water temperatures with and without dams in place. In general, the reservoirs smooth out diurnal temperature fluctuations in the downstream channel. The simulations show that after dam removal there will be larger diurnal fluctuations. The simulations also show that dam removal would potentially increase the temperatures from February to April because the cold water pool is removed, and decrease the temperatures from August to January. There may be considerable uncertainty in these estimates because of the complicated processes in the reservoirs that affect water temperatures. A system wide energy budget would indicate that removing the dams would decrease water temperatures overall because a large surface area exposed to solar radiation is removed. Also, removing the dams would increase the daily and seasonal variability in temperature because the large reservoirs are removed.

Recommendations for Feasibility Design

The following tasks are recommended for development of feasibility designs and cost estimates for the dam removals:

1. Extensive data would be required to define the existing conditions at each of the dams to advance to a feasibility-level stage of design. This would include the review of detailed drawings of the existing dams and all appurtenant structures, close examination of construction photographs, field measurements, and possibly some concrete coring and materials testing. (The Team’s limited review revealed some drawings and photographs not previously used by GEC for the appraisal studies. Existing half-size prints should be replaced by full-size drawings if possible.)
2. The screening, testing, and identification of any hazardous materials.

3. The determination of structure removal limits at each site, and site restoration requirements.
4. The identification of suitable waste disposal sites, including potential locations for on-site disposal, as well as locations of public landfill sites, with estimated haul distances to all sites.
5. Access road conditions to project sites, including load limits on bridges and culverts.
6. The operating condition and discharge capacity of all hydraulic structures available for reservoir drawdown and streamflow diversion, including the diversion tunnels at Iron Gate and Copco No. 1 Dams, and the diversion conduits at J.C. Boyle Dam. This would include the impact of sediment and woody debris on low-level outlets.
7. Complete inventory lists of all mechanical and electrical items to be removed, and any salvage requirements.
8. The establishment of any applicable construction constraints to avoid or mitigate environmental impacts.
9. Flood hydrology information for each project site, including the development of frequency flood hydrographs for streamflow diversion during dam removal.
10. The identification of any potential impacts within the reservoir areas due to drawdown, which could expose bridge piers, retaining walls, other structures, and utilities (including water supply pipelines, transmission lines, and communication cables) to potential scour or other damage. This would likely include reconstruction of the existing Yreka water supply pipeline crossing Iron Gate Reservoir.
11. An evaluation of the slopes around each reservoir rim should be performed to determine whether there is any history of large landslides in the geologic units that exist in the reservoir. Reservoir drawdown rates that exceed 1 ft/day should be studied in more detail before being adopted.
12. The determination of sediment management and environmental mitigation requirements.

Most of the analyses of sediment impacts have been somewhere between an appraisal-level and feasibility-level study. The reports generally acknowledge the fact that many analyses still need to be performed. A task list related to sediment and water quality concerns follows:

1. Determine number of additional sediment samples necessary to fully characterize reservoir sediment. Drilling will have to be performed at additional locations and through the entire sediment deposit.
2. Establish suspended sediment monitoring stations upstream and downstream of dams. This will provide baseline suspended sediment data and monitoring data during and after dam removal. PacifiCorp (2004b) has provided initial estimates of sediment loads in the river, but these need to be verified by field measurements and any changes to suspended sediment concentrations need to be documented.
3. Estimate water quality conditions during dam removal and immediately after dam removal. The current (with dams in place) and future (without dams in place)

water temperature and water quality conditions have been documented in Dunsmoor and Huntington (2006), Bartholow et al. (2005), and FERC (2007). However, there needs to be an assessment of water quality conditions during the period sediment is being eroded from the reservoirs. The modeled reach should extend as far as impacts are significant.

4. Develop a baseline flood map for all areas downstream of Copco No. 1 and Iron Gate Dams. (Although it is unlikely that the project will affect flood elevations, baseline conditions should be documented as a precaution).
5. Develop relationships for the erosion rates of silt and clay sediment in the lower two reservoirs for use in a numerical model. Estimate engineering properties of silt and clay sediments in reservoir deposits under drained and saturated conditions. Estimate the drainage characteristics of the reservoir sediment. A field scale test where a reservoir is drawn down to eroded reservoir sediment would assist in the development of these relationships.
6. Develop erosion and sediment transport model for entire volume of reservoir material for the drawdown period and after dam removal.
7. Analyze various drawdown and removal strategies. To date, the analysis has seemed to focus on removing all dams simultaneously. Sequential removal may need to be analyzed because construction issues, downstream water quality constraints, and outlet control issues could limit the simultaneous removal.
8. Analyze issues associated with opening the low level outlets. For example, the sediment currently submerges the diversion outlets proposed to drain the reservoirs at Copco No. 1 and J.C. Boyle Dams. If the sediment is consolidated, it may have to be excavated before the outlets are functional. Also, the extremely high concentrations resulting from the initial flush of opening these outlets without excavation have not been analyzed.
9. Calculate channel and floodplain deposition downstream of Iron Gate and Copco No. 1 Dams. It is unlikely that there will be significant channel deposition downstream of these dams, however, this should be verified.
10. Estimate duration and magnitude of suspended sediment concentrations downstream of Copco No. 1 and Iron Gate Dams after their removal for various dam removal strategies. Estimate uncertainty of estimates to capture the range of possible outcomes. Current estimates of the impacts are not based upon a process-based model of sediment erosion, but rather on simplified assumptions that all sediment will erode during reservoir drawdown.
11. Estimate impacts of additional fine sediment delivery to estuary and ocean.
12. Estimate effect of dam removal on riparian species. The change in flow in the reaches below the dams should, in general, improve the health of the riparian ecosystem. However, the expected changes should be documented.
13. Develop a sediment monitoring program, including data collection, for use before and after dam removal.

Signatures

Prepared:
The following served on the TSC Review Team for the Klamath River Dam Removals A/E Study and prepared this report.

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Waterways and Concrete Dams Group
2/12/09 Date

Carlton Smith, Construction Management Group
2/16/09 Date

Dan Maag, Estimating, Specifications, & Value Program Group
2/12/09 Date

Blair Greimann, Sedimentation and River Hydraulics Group
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Steve Young, Geotechnical Engineering Group 1
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Bob Zelenka, Hydraulic Equipment Group
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